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**Ageing in Mexico:
Modelling health and frailty and its
relationship to the use of health services and
the supply of informal care**

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**Thesis submitted for the degree of
Doctor of Philosophy at the University of London**

**London School of Hygiene and Tropical Medicine
Public Health and Policy Department
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2009

Statement of Work

Data for the research come from the two existing waves of the Mexican Health and Ageing Study, MHAS (2001 and 2003). This is a prospective panel study of health and aging in Mexico which includes a nationally representative sample of population 50 years and older.

All the data sets and documentation linked to the MHAS are of public access.

I have read and understood the School's definition of plagiarism and cheating given in the Research Degrees Handbook. I declare that this thesis is my own work, and that I have acknowledged all results and quotations from the published or unpublished work of other people.

Mariana Lopez-Ortega

Confirmed by

Professor John Cairns
Supervisor

2009

Abstract

Mexico is still a “young” country with pressing burdens on education, especially at secondary and high school levels, and high percentages of the population entering the work force each year. Yet, it will complete its “demographic transition” in the next 20-25 years with a rapid increase in the percentage of population 65 years and older.

As with most Latin American countries, Mexico is experiencing what experts call a “mixed” epidemiological transition with increasing trends in prevalence of chronic diseases and a marked decrease in communicable diseases in some areas, but with a continuing moderate or high incidence of the latter in some regions of the country. In addition, there are no long-term care programmes that cater to the specific health and social care needs of the older population. Services for the elderly are comprised of isolated strategies mainly recreational and information programmes, and health services similar to those provided to all other age/condition groups in the country. At the moment, social development and health sectors are unprepared to cater for the needs of the increasing elderly population.

Currently, the majority of the older population live with their children, or other close relatives, and most of the care provided to them is done at home by their family members. Nevertheless, changes in fertility rates, constant rural-urban migration within Mexico and international migration, women’s increasing participation in the labour force, among other factors have changed family size and composition and may pose future challenges to the availability of household care and support.

Given the rapid ageing process Mexico is going through, the absence of dedicated strategies for the older population and the possible decrease in availability of informal care, there is a pressing need to have detailed information on the conditions of the older population and how they are experiencing the ageing process. Mainly, on their health and disability status, on their use of services by the elderly, and on the characteristics of the informal care that is provided to them.

The main objective of this research is to generate significant information in order to provide health system institutions with information on specific needs and on the provision of social and health care services for the elderly in Mexico in the next decades.

The aim of the thesis was to generate information on the dynamics of the ageing process in Mexico and how the Mexican population is facing old age. This was done by exploring four main topics.

First, a comprehensive study of their health and disability status was done, including the generation of a Frailty Index in order to have an additional indicator of their overall health and frailty status at individual and population level.

Secondly, overall survival in the Mexican ageing population was investigated. Through the analysis, possible differences between sub-samples of the population were explored.

Given that there are no formal long-term care services for the older population in Mexico, the remaining topics are related to the care for this population group. On one hand, the thesis explores the use of health services by the ageing population in Mexico. This includes the use of different types of care such as general practitioner, specialist doctors, as well as inpatient and outpatient hospital visits. On the other hand, it explores the supply of informal care for the older population by their (co-resident and non-resident) children.

The thesis then addresses future challenges regarding the ageing process and formal and informal care-giving. Finally, following the identified challenges, the thesis includes recommendations for future research and inputs for future – health and social—ageing policies and strategies in Mexico.

Data for the research come from the two existing waves of the Mexican Health and Ageing Study, MHAS (2001 and 2003). This is a prospective panel study of health and aging in Mexico which includes a nationally representative sample of population 50 years and older.

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Chapter 1 Introduction

Population ageing and its impacts on productivity, economic growth, and health expenditures have been mainly associated with developed countries. However, at the moment, most countries are starting to see sustained increase in their older population, and are expected to experience relatively old age structures, with high proportion of population 60 years and older before 2020. Data from the United Nations (Mirkin and Weinberger, 2001) show that the proportion of the world's population aged 60 years or over is projected to increase from about 10 per cent in 2000 to 13 per cent by 2020, and likely over 20 percent by the year 2050.

According to work from the Pan American Health Organisation, the annual growth rate of the population 60 years and older in Latin America and the Caribbean, LAC is 3.45 per cent. As a result, this group will increase from 42 million in 2000 to 100 million in 2025, representing 8% of total population in the year 2000 and 14% by the year 2025. Within Latin America, seven countries account for two thirds of the total older population in the region: Argentina, Brazil, Chile, Mexico, Paraguay, and Uruguay, with Brazil and Mexico alone having 50% of all older persons in the region. In these two countries, approximately 75% of older people live in cities (Pan American Health Organisation and Merck Institute of Aging & Health, 2004).

In addition, they state that the ageing process in LAC will not be an easy one, noting that:

"...unlike in the industrialized world, the explosion in the number of older adults is taking place in the midst of the fragile economies, rising poverty levels, expanding rather than contracting social and economic inequalities, and contracting rather than expanding access to collectively financed services and resources. Consequently, cohorts of seniors reaching 60 in the period 2000-2010 in LAC are likely to experience worse health and more disability than those observed among elders in developed countries" (p. II).

In spite of this, they see a window of opportunity in most LAC countries where even when the proportion of young population is decreasing, it is large, and the proportion of older people is still small. This could present the region with different opportunities that could increase their economic and social development, if they act immediately.

Within this context, Mexico is still a "young" country with pressing burdens on education, especially middle and high school level, and high percentage of

population entering the work force each year, and is also expected to complete its demographic transition in the next 10-15 years (Zúñiga and García, 2008). Unfortunately, for a large proportion of people, reaching old age will likely be in a context of difficult conditions

Currently in Mexico, extended families where older adults live with their children or other relatives are still the norm (Zúñiga and García, 2008). This family support has prevented a large number of older people from falling into bad/worse health; it has even prevented some of them falling into poverty by preventing ill-health, property loss, among other problems.

Most informal care in Mexico has historically been provided by women: spouses, daughters, and daughters-in-law. However, their increasing incorporation in the labour market, their expressed desire for smaller families, rural-urban and international migration, among other factors are expected to leave a void due to an important decrease in informal care in the future as families may no longer be able to fulfil their traditional role as main social and economic support and providers of care.

In addition, Mexico is a country characterized by high segmentation of the health system and no formal long-term care health and social services are available to cater for the needs of the older population. All this is happening in a setting of high competition for scarce public funds.

At the moment, Mexico can benefit from a window of opportunity in more than one way. First, it is still a young country that can benefit from the demographic bonus in which a high proportion of the country is of working age, the dependency ratio is still low and can be used as an opportunity to impulse development and economic growth.

Second, it has the opportunity to learn from other countries' successful experiences, failures, and reforms in Long Term Care services for the old and chronically ill, and use this feedback to design and implement appropriate health and social care programmes which are needed to a great extent in Mexico.

If the country fails to respond to this issue, and continues to leave most of the care provision within the household and with no national and local strategies to care for the older population, especially for those in most disadvantaged situations, the negative impact on the health, social, and overall wellbeing of the older population can be vast. In addition, the impact this may have on the already scarce health services they receive and its financing is of consideration.

As a society, we cannot allow for these disadvantages, poor conditions, and lack of specialised health and social care to continue for the older population. There must be political will and social responsibility to recognise the value of the older population, all they can contribute and have already contributed, and move forward towards the generation of needed policies to cater for their current needs, but most pressing, for the future when their needs or at least their numbers will be much higher. Equally, the support to their families and social networks has to be addressed.

Due possibly to other pressing needs related to the young and the population of working age, interest and concern for issues regarding the older population in Mexico is very recent. Relevant work has been done, but surely more is needed, especially in order to have a more comprehensive understanding of the ageing population, how they are experiencing this ageing process as individuals and very importantly, as part of the society in which they live.

In this context, there is a great need for research on the current conditions of the older population that provides a multi-dimensional and comprehensive assessment of their health and social conditions, and their wellbeing. This in turn will allow the planning of future services that could cater better for their specific needs.

1.1 *Current knowledge gaps*

When preparing my research proposal and upgrading document, it became clear that there were key issues where further research on the older population in Mexico was needed.

Some of these issues had been identified already but in most cases little or no further work had been done. More than ten years after the first studies focusing on older individuals and their conclusions regarding the need for making the health and wellbeing of an ageing population a priority, there are still no comprehensive social and health care strategies or programmes for the old. A research agenda has been increasingly developed and it is hoped that it will support the adequate planning and allocation of funds and services for older people in Mexico.

A central reflection on the main issues around the ageing process in Mexico and on the further research needed have been generated by Gutiérrez Robledo and García Mayo (2005). Among the most relevant issues they present is the need to investigate how the population is experiencing the ageing process in Mexico, its progression through frailty and disability, and whether it follows a path of

compression or expansion of morbidity. Secondly, they note the need to tackle poverty not just for children and working age individuals but for the older population and in particular women who account for a larger proportion of this group and often in much more disadvantage conditions. Third, the need to recover the positive attitude towards the older population who have already contributed to the economy and society, the respect towards them, and a wide promotion of their human rights are noted.

Another issue mentioned is the need for specialised services that cater for the needs of the older population, concentrating not only on health services but on the practically non-existent community social care services. In their document, Gutiérrez Robledo and García Mayo consider comprehensive long-term care in all its components, and finding ways to support the families of those in need of care as a fundamental need.

Taking this into consideration and a review of the literature, there were several topics where research gaps were identified. One of them has to do with research where, to my knowledge, no work has been published mainly due to a previous lack of adequate data. Other involves complementing or expanding existing research by using more complex estimation methods; by using recently available data with national representation of the ageing population in Mexico; and by including predictors that had not been previously used.

Regarding new research, the topic is survival analysis. Although there is a wide array of studies on survival in Mexico, none have as their focus overall survival (risk of mortality) of the population 50 years and older. Most studies, even the few that focus on older population groups, estimate survival after particular events such as surgery or medical treatment, or concentrate on a group of the population with some specific illness or disease such as cancer, diabetes, hypertension, among others. Given the appropriate data to undertake this research is available, an analysis of survival of this sample of the population in Mexico was considered a high priority.

The first and most relevant issue in extending existing work is related to the supply of informal care for the older population in Mexico. To date, work on the provision of informal care to the older population in Mexico has mainly concentrated on small samples at local level (Robles-Silva, 2008). In addition, the only existing work using a nationally representative sample of people 60 years and over, in spite of recognising their importance, could not include detailed analyses of characteristics

of the carers or on the time spent providing such care, given that the data source did not contain such information (Montes de Oca Zavala, 1999). Finally, some work has been done on the intergenerational transfers and support between the middle-aged and older generations in Mexico, mainly financial transfers and general support.

The second issue refers to the way in which older individuals are experiencing the ageing process regarding disability and frailty. Although there are a few studies on disability of the older population in Mexico, they mainly consider the likelihood of being disabled expressed as difficulty in doing different activities and possible determinants of disability (Barrantes-Monge et al., 2007; Gonzalez and Ham-Chande, 2007; Palloni, Pinto-Aguirre and Pelaez 2002). Therefore, further research that investigates not only the likelihood of being disabled, but the intensity of such disability, and the factors that determine their particular condition was felt to be also needed.

In this same line, having a comprehensive indicator of wellbeing of the ageing population in Mexico is considered of great potential value to the design, planning, and implementation of future long-term care strategies. For this reason, the generation of a Frailty Index, following the work of Canadian researchers, and using a nationally representative sample of the population 50 years and older was considered. To my knowledge, there is one work in progress that replicates these methods (García-González et al., In press). However, the analyses are done only for the population 75 years and older. In light of the need for planning preventive, curative, and social care strategies, it was considered indispensable to generate information for a larger sample.

Finally, the issue of utilisation of health services by the older population in Mexico was considered. Until recently when nationally representative data of the ageing Mexican population became available, most studies on utilisation of services had to focus on basic statistics such as number of nights at hospital, medical doctor visits by age group, sex, and other indicators. As with other issues, once data was available¹, more studies were done. However, given that existing work mainly concentrates on estimating the probability of seeking services it was thought that

¹ Two sets of surveys have allowed for more detailed research. On one hand, the National Health Surveys (1994, 2000, and 2006) made available for the first time detailed data on service utilisation profiles at national and regional level, by reason-type of care, and institution of care. On the other hand, the Study on Health and Well-being of the Elderly, SABE (for its acronym in Spanish), and the Mexican Health and Ageing Study, MHAS made available for the first time a representative sample of older people living in the metropolitan area of Mexico City, and at national level, respectively. Both studies include a section on utilisation of health services.

further work which in addition included analyses of the amount of services was highly relevant and should be undertaken.

It is important to note that from the beginning, the need to have projections of the future conditions of the older population, whereas their health status, utilisation of health services, and availability of informal care was clearly identified. Unfortunately, besides the fact that this task is beyond the scope of the present work, data available does not allow for sound longitudinal analysis that allows undertaking such work. As with other issues still in need to be explored, this remains a crucial one.

1.2 Purpose and contents of the thesis

1.2.1 Purpose

The aim of this research is to improve the understanding of the determinants of the wellbeing of the ageing population in Mexico, and of the way this group are experiencing the ageing process as individuals, but also as part of society.

A further aim is to identify key issues that will inform the design and planning of future strategies for long-term health and social care for the older population in Mexico and the implementation of long-term health and social care that caters for their specific needs.

With this in mind, the specific objectives of this research are as follows.

1. To estimate disability in everyday activities for a sample of individuals 50 years and older in Mexico, including the probability of being disabled and the intensity or level of disability;
2. To explore frailty and wellbeing in the ageing Mexican population and its determinants by generating a Frailty Index;
3. To investigate survival (risk of mortality) in the ageing population in Mexico and its determinants;
4. To investigate the determinants of the demand for formal care by the older population in Mexico. This study will concentrate on demand for health care services because there are no established formal long-term care programmes for the older people in Mexico;
5. To estimate the supply of informal care for the older population in their household;

6. To derive from the key findings, recommendations for future research and for the design and planning of long-term health and social care for older people in Mexico.

A cross-cutting objective throughout the thesis was to investigate differences between groups with a major focus on gender inequality, differences due to ethnic or indigenous background, and among different socio-economic groups.

1.2.2 Contents

The thesis has the following sections. After the Introduction, Chapter 2 presents an overall background to the main issues related to the research, the ageing process in Mexico, the health care system in Mexico and the few other services available for the older population.

Chapters 3 to 5 investigate the main issues related to health and mortality of a sample of individuals 50 years and older in Mexico. Chapter 3 introduces the concepts of health status, disability, and frailty and their operationalisation in the general empirical work with respect to the older Mexican population

Chapter 4 generates a Frailty Index for the ageing population in Mexico, while Chapter 5 explores the main factors determining the probability of being disabled and the level or intensity of such disability.

Chapter 6 investigates overall survival in this population group. This chapter combines the Frailty Index with additional predictors in order to predict risk of mortality. The findings from these chapters show significant differences between men and women regarding their frailty status and risk of mortality. While women accumulate on average more deficits or adverse health conditions and shower higher frailty, men have a significant higher risk of mortality. In addition, significant differences in frailty status and survival were found by different socio-economic characteristics.

Chapter 7 uses the findings on disability and frailty of the ageing population in order to estimate the main factors that determine their utilisation of health services. The utilisation of three services is explored: medical doctor or physician visits, outpatient (same-day) hospital procedures (including minor surgery, treatments, etc.), and inpatient hospital services (nights spent in hospital). It was interesting to find that need factors, in particular frailty not age that mainly determines use of services. Enabling factors such as size of locality also turned out to be significant.

Chapter 8 estimates the supply of informal care for the older population in Mexico. It presents an analysis of the care and help with everyday activities provided by co-resident and non-resident children to the sample of older people. Main findings indicate that women have much higher likelihood of being carers and the frailty and health status of the older person are more significant determinants of provision of care than the carers characteristics. Finally, the study finds significant differences in the factors that determine both the decision to care and the time care is provided between children living with their parents and non-resident children.

Chapters 3 to 8 each include a section with a discussion of the research findings, the limitations of the research data and methodology, and further research recommendations.

Finally, Chapter 9 presents the main contributions of the research, recommendations for future policies in Mexico and for similar countries. In addition, it introduces a summary of recommendations for further research.

In generating these studies it was evident from the start that there was an important decrease in the sample size in the estimations due to missing values. Mainly, given that Stata10© (StataCorp, 2007) works based on complete-case analyses, that is with observations that have information for all the variables included in the models, a large part of the sample would have been lost in the estimations; in some cases in more than half of total sample.

Given that working with complete-cases only poses the risk of biased or non-robust estimations and in consequence I decided to perform mechanisms to work with full sample and not complete-cases. To this end, multiple imputation procedures were performed. A detailed description on missing data, multiple imputation techniques, and the multiple imputation procedures used are included in Chapter 4.

Appendices include additional figures and/or tables with results from the different estimations. The complete multiple imputation procedure used for the research is included in this section.

Chapter 2 Background

2.1 Global

The twentieth century witnessed almost worldwide, dramatic decreases in fertility and mortality. These improvements brought transformations not only to the demographic profile around the world, but to the social and economic arenas. There have been significant changes in family size, in patterns of co-residence, in labour force participation, in the sustainability of pension and retirement schemes, among many others.

While at the time of the first World Assembly on Ageing in 1982 the main focus was on the ageing process in the more developed countries, twenty years later at the second World Assembly in Madrid, it was clear that one of the main concerns was the rapid ageing process that a large part of the developing world was already going through. The increase in numbers of older persons will be greatest and most rapid in developing countries where this population group is expected to almost quadruple on average by the year 2050. While in 1950 8% of the total population was 60 years and older, this number reached 10% by the year 2000 and is projected to reach 21% in 2050. For Latin America and the Caribbean the figures are respectively 6%, 8%, and 24% (United Nations Population Division, 2005; Wiener, 2003).

It has been decades since different international organizations such as the United Nations and the Organization for Economic Co-operation and Development, OECD as well as other institutions in many countries recognized the relevance of the ongoing ageing process and increased their research on many related issues. Major concerns have developed around the possible impacts of ageing on such diverse issues as the provision of health and social care services, the use of health care services, its impact on the labour force, the financial resources and expenditures allocated for older population's health care, among many others. In addition, new techniques have been developed for measuring demographic changes and health status such as population projections and summary measures of population health.

Although equally relevant, the profound changes experienced in intergenerational relations and family-social structures and the impact these changes may have on future supply of informal care for the older population, have been much less explored.

Informal care for older persons is known to be the main source of care for the older population, whether in developed, developing, or the least developed countries.

Perhaps the first large scale effort to recognise and measure the relevance of informal support as part of long-term care for older persons was by the World Health Organisation as part of their Initiative on Long-term care. A volume dedicated to *key policy issues in long-term care* establishes in two of its chapters the relevance of the family in providing this care, the need to balance responsibilities between society and families in providing care, the impact of informal care on other arenas such as labour force participation of women, and the opportunity costs of caring, whether informal care substitutes for formal care, or whether they complement each other, among other issues (Pijl, 2003; Wiener, 2003).

More recently, the Madrid Plan of Action on Ageing, a result of the second World Assembly on Ageing in 2002, establishes the *imperative issue of care and support* for caregivers in its Priority direction III: Ensuring enabling and supportive environments for older persons (United Nations, 2002).

The plan establishes the need to provide care for older persons, and of strengthening and reinforcing the care-giving systems with public policies. The Plan also recognises the need to alleviate the burden and opportunity costs generated by care-giving for family members, especially by women, and in demanding situations such as the simultaneous care of children and older persons, caring for AIDS orphans, among other issues. The needed support should be solved by providing a continuum of affordable care options, whereas financial support, training and respite for the carers, financial support for older persons, or by providing care options in the home or/and institutional settings.

Latin American and Caribbean countries who signed the Madrid Plan, participated in the Regional Intergovernmental Conference on Ageing: Towards a Regional Strategy for the Implementation in Latin America and the Caribbean of the Madrid International Plan of Action on Ageing, held in Santiago, Chile, in November 2003. The regional strategy made social and family support one of their main objectives. The main actions recommended to move this forward were: to increase availability, sustainability, and suitability of social support systems for older persons by creating and/or improving the infrastructure of social and community services at local level; generate strategies to support families/persons that care for older persons; sensitise people, especially men, to the importance of creating and maintaining

networks of family members and friends or communities through the life course; to ensure gender equity in access to the social protection system and other sources of formal support, among others (Economic Commission for Latin America and the Caribbean Regional, 2003).

Long-term care has been defined by the World Health Organisation as the institutional or home-based activities that are either formally or informally provided. It includes activities carried out for those that are not fully capable of self-care on a long-term basis by informal caregivers (family and friends), by formal caregivers including professionals and para-professionals (health, social, and others), as well as by traditional caregivers and volunteers.

Long-term care includes a broad range of services such as help with personal care (e.g. bathing and grooming), household chores (e.g. meal preparation and cleaning), life management (e.g. shopping, medication management, and transportation), assistive devices (e.g. canes and walkers), advanced technologies (e.g. emergency alert systems and computerized medication reminders), and home modifications (e.g. ramps and hand rails) (World Health Organization, 2002). The combination varies widely among and within countries and although in some it includes care for people of all ages it usually refers to the care of older persons. A wide array of combination of long-term care services provided exists in several countries.

As concerns for financing Long-term care and the type of services needed in the future have been increasing, several countries have made extensive research efforts in order to study these issues. Some of the largest studies have been developed for the United Kingdom, the US, and Australia, and in international organisations such as the Organisation for Economic Co-operation and Development, OECD. Except for work in these countries there appears to be only a small amount of international literature on projections for long-term care² (Pickard et al., 2000).

Work for the UK includes projections up to 2031 of the numbers of elderly people with different levels of dependency by age group, gender, and household type; the estimated demand for long-term care services by type of service (including informal care) under current patterns of utilisation and variants that may display greater

² In the UK extensive work has been done by the Personal Social Services Research Unit (PSSRU) a collaboration between departments at the University of Kent at Canterbury, the London School of Economics and Political Science (LSE), and the University of Manchester; by the Economic and Social Research Council (ESRC) research group for Simulation in Social Policy in an Ageing Society, ERSC-Sage group; The Royal Commission on Long-term care; and the Institute of Actuaries within the Institute for Public Policy Research-Department of Health.

cost-effectiveness; and expenditure by funding source given national patterns of costs and current funding mechanisms or specified variants (Wittenberg R et al., 1998). In addition, the ESRC-SAGE project developed dynamic micro-simulation models of social policies to provide evidence for the assessment of the impact of different policy options for the older population, allowing for evidence-based social policy projections in this area (Evandrou et al., 2001; Evandrou et al., 2003).

On the other hand, the Royal Commission on Long-term care in their 1999 report *With Respect To Old Age: Long-Term Care- Rights and Responsibilities* (The Royal Commission on Long Term Care 1999) examines short and long-term options for sustainable funding of long-term care in the UK for those living in the community and those living in institutions. Also, it investigates how the costs of such care should be shared between public institutions and individuals, including cost projections to the year 2050 based on the models generated by the Personal Social Services Research Unit, PSSRU.

The Australian Institute of Health and Welfare for example, has undertaken extensive work on making projections on health and social care issues. They have developed projections on diverse subjects such as cancer incidence 2002-2011 (MCDermid, 2005), health care expenditure by specific diseases 2003-2033 (Goss, 2008), and on the supply of informal care 2003-2013 (Jenkins et al., 2003) to mention just a few. In addition, projections on the future demand for and supply of informal care providers for people 65 years and older in Australia to 2050 have been developed by the National Centre for Social and Economic Modelling, NATSEM at the University of Canberra. Their models are based on population and household projections from the Australian Bureau of Statistics, as well as data on current and likely future care needs based on the Australian Bureau of Statistics' Disability, Ageing, and Carers Survey (National Centre for Social and Economic Modelling, 2004).

Finally, an example of work from the US includes the Urban Institute's dynamic micro-simulation models of the U.S. population, DYNASIM3, which have been used to generate projections with respect to alternative systems of social security, disability status, pension coverage; long-term care benefits claims, among others (Favreault and Smith, 2004).

It is clear from the results, policy implications, and recommendations from these studies that comprehensive research on the overall well being of the older population is needed when developing long-term care policies and services, and

countries such as Mexico should concentrate major efforts to do so. This should facilitate the development of better strategies that truly cater at national and local levels, for current and future needs of the ageing population.

2.2 Mexico

As with most developing and middle-income countries, Mexico is currently going through rapid demographic and epidemiological transitions with diverse impacts on its social arrangements, health system, among other areas. By the year 2000 6.9% of the population was 60 years old or more and it is estimated that by 2050 one out of four Mexicans will be more than 60 years old (Partida Bush, 2004). The transitions that brought about this ageing of the population have the following key determinants.

First, as a result of major national vaccination campaigns, national public health strategies to prevent and control communicable diseases, and the creation and development of the health system in Mexico launched in the first decades of the 20th century, life expectancy at birth increased rapidly and significantly. Global mortality and significant decrease in infant mortality implied a shift from 182 deaths a year for every 1,000 live births in 1930, to 21 in 2002 (Consejo Nacional de Población, 2000). In the period from 1930 to 1950, life expectancy for women and men was 36.9 and 34.9 respectively, and by 2000 it had more than doubled reaching 77 and 72 respectively (Consejo Nacional de Población, 2000; Partida Bush, 2004). These figures have been projected to reach 77.8 and 73.1 in the year 2010 (Partida Bush, 2006).

Secondly, also with large government funding and support, nationwide family planning policies started in the late 1960s allowing couples to have wider options to decide on the number of children they wanted. Contraceptive prevalence has since then steadily increased reaching 52.7% in 1987, 68.5% in 1997 and according to the latest reproductive health survey, and 73.7% of all women of reproductive age in the period 2000-2005 (Consejo Nacional de Población, 1999; Secretaría de Salud, 2006).

As family planning became more widely available, and different cultural and social transformations took place, women were increasingly able to enter the labour force and other arenas outside the household such as formal education, political arenas, etc. This resulted in equally relevant changes in family structures and dynamics.

Mexican women's fecundity decreased from 7.0 children on average in 1960, to 2.4 on average in 2000 and 2.1 in 2003 (Partida Bush, 2004). With this, the traditional family structure and size also changed significantly. In addition, changes in women's labour market participation contributed to these changes. According to different surveys, while in 1970 17 out of 100 economically active women worked outside the household, these numbers increased to 20 out of 100 in 1990, and 31 out of 100 in 2000. Thus, families composed of parents and children have seen a significant decrease in the number of children in the household, while the number of extended and single-person households has steadily increased.

The final key determinant of the demographic transition which has been equally relevant in the last decades is migration. In most of the country, the rural to urban migration has gradually transformed Mexico from a predominantly rural to predominantly urban country by going from 42.6% urban population in 1950, to 58.7% in 1970 and 76.5% in 2005 (Instituto Nacional de Estadística Geografía e Informática, 2008). This has created different needs and demand for services in metropolitan areas with respect to education, health, and recreation among others.

On the other hand, international migration has been highly significant in the last decades showing predominantly negative balance with much more people leaving the country, mainly for the United States of America. This situation is highly complex and involves economic, political, and social factors on both sides of the border that are evidently beyond the scope of this thesis. However, it is important to note that migration rates reached 0.2% in 1990 and around 0.3% of the total population or approximately 200 000 people a year in the period 2000-2005 (Partida Bush 2006).

Each of these changes in family size and composition, in traditional roles, and increasing migration has had significant implications for the ageing population, particularly in terms of their health and social care needs.

Although the National Population Council, CONAPO estimated that 73% of the population aged 60+ years in Mexico in 2000 lived with their children or other close relatives (Zúñiga and García, 2008) and older generations in general currently live with their children (De Vos et al., 2004), the above mentioned changes will pose future challenges to the availability of household care and support. This is already observed in an important number of rural and remote areas where younger generations have moved and left the older generations alone or in many cases in

charge of their grandchildren. Without the support of the younger generations, many older adults have to continue working into very advanced ages.

The link between poverty and urban/rural differences in Mexico has been widely documented. In terms of health status, large disadvantages in rural areas are reflected in higher excess deaths and healthy life years lost as well as much higher coexistence of communicable and non-communicable chronic diseases than in urban areas. Thus, while in one extreme there are municipalities where the main causes of death are still concentrated in conditions like diarrhoea and respiratory tract infections, other municipalities show causes of death similar to developed countries such as malignant tumours, diabetes, and accidents (Frenk et al., 1994; Zurita et al., 2003).

In a study exploring health by ethnic status Jose Luis Torres and colleagues also found significant differences. For example, in the period 1996-1999, while in municipalities with 5% of total population belonging to an indigenous group life expectancy was 65 years for men, it was 62 years in those with 75% indigenous population. The national estimate at this time was 70 years for men. Adult mortality calculated as the probability of dying between the ages of 15 and 45 years showed rates of 146 and 169 for each thousand deaths respectively. In addition, analyses of the main causes of death showed that in municipalities with a higher concentration of indigenous population the main causes were linked to preventable causes and communicable diseases while in those with the lowest concentration they were concentrated in non-communicable chronic diseases (Torres JL et al., 2003).

A large number of people live in rural communities which are usually remote, hard-to-access, and marginalised with few or precarious services available creating highly vulnerable conditions, particularly for the oldest population. For them, this usually means that inequalities throughout the life cycle have a greater impact in later life and translate into earlier occurrence of different outcomes such as frailty, disability, and ultimately death. In addition, lack of knowledge about health care and the scarce access to health and social services implies delays in seeking health care (if at all), or greater use of alternative methods such as folk medicine. Although research in this topic at national level is needed, smaller scale studies with an important qualitative content are a relevant first indicator of these conditions (Salgado de Snyder, 2003; Salgado de Snyder et al., 2005).

On the other hand, work on the relation between social inequalities or socioeconomic differences and health status for the general population in Mexico has started to be explored. In one of the first empirical analysis made for the general population, Martinez Valle (2009) uses individual data from the Second National Health Survey (ENSA II) to study the effect of social class on self-rated health. He concludes that social inequality negatively influences health through a differential exposure and an unequal distribution of resources across the class spectrum: the lower the social class, the poorer the perception of health. In addition, he notes that the results show that living in more deprived regions had a further negative effect on health compared to those living in wealthier regions.

Using a social exclusion index generated by the National Council of Population, CONAPO³, Zurita and colleagues divided the country into 713 micro-regions and compared their health status. Looking at Life Expectancy at Birth they found a 13 year difference between the municipality with lowest index score (most excluded, highest inequality and poverty levels) and that with the highest index score, with values ranging from 58 years life expectancy to 71 years. This was also found when looking at infant mortality rates where the difference between the lowest and the highest scores is not only significant but the number of deaths keeps increasing as the exclusion index or worse conditions increase. Thus, in the period of 1996-1999 while most of the country showed rates of 20 infant deaths for each thousand live births, an important number of regions reached rates of 40 deaths and in the extreme, three regions reached rates higher than 80 deaths (Zurita et al., 2003).

Finally, investigating the impact of current socioeconomic differences on health status, Smith and Goldman (2007) found that similar to what has been observed in industrialised countries, in urban areas in Mexico higher education, income, and wealth are significantly associated with better health outcomes. These effects did not hold for their less urban sample where the effects of health inequalities due to socioeconomic status were weaker. The authors discuss several possible reasons for these contrasting results. First, better socioeconomic status can lead to better opportunities in general, to higher health literacy, better living conditions, and working conditions. However, in less urban areas, where socioeconomic

³ The Index is constructed using the following indicators: proportion of the population which is illiterate, and that did not finish primary school; the proportion of household residents that have no access to sanitary sewage, potable water and energy; proportion of residents in households with dirt floor; proportion of residents in overcrowded households; proportion of residents in households in the lowest income deciles; and municipalities with population less than 2,500 people. Extensive information can be found at: www.conapo.gob.mx

opportunities and access to medical care tend to be constrained regardless of level of SES, estimates show that SES-related health inequalities are weaker.

In addition, they mention that family support systems may be stronger in less urban areas serving as equalising factor in old age, as well as the fact that it is likely that conventional measures of socioeconomic status such as education attainment are poor indicators in places with general low levels of educational attainment and were residents with higher levels may still experience low living standards.

Another issue that has been recently explored in the literature is to use a life course approach to investigate the impact of socioeconomic and early childhood conditions on ageing and health in later life. One of the main conclusions of such work is that population differentials in health in later life are a direct result of lifetime differentials in socioeconomic factors (Crimmins, Kim, and Seeman, 2009).

For Mexico, only a couple of studies that explore these issues were found. For example, Kohler and Soldo (2004) use the Mexican Health and Ageing Study (MHAS) to study the impact of early life events, current and childhood socioeconomic conditions on the health status of older adults in Mexico. Using childhood antecedents or socioeconomic conditions such as "going to bed generally hungry" and "had inside toilet" and "had serious health problem before age 10", as well as parental background conditions such as their educational attainment, the authors try to identify their impact on having an illness or disease in later life. Specifically, they investigate the link between these conditions and the onset of type 2 diabetes which has had an extremely high incidence in Mexico in recent years. Their results show that the probability of having type 2 diabetes in later life is significantly related to socio-demographic factors such as sex, age, educational attainment, and partnership status. In addition, having serious illnesses in childhood was associated with higher probabilities of developing type 2 diabetes in later life, while higher maternal educational attainment was associated with lower probabilities of developing it.

In a similar analysis using MHAS, Grimard, Laszlo, and Lim (2008) explore the long-term effects of childhood and adult socio-economic status on health status in later life. Their results show that these are strong determinants with conditions such as going to bed hungry (at/before age 10) having long-lasting effects on health since they are associated with remaining in good health from 2001 to 2003, even after controlling for adult conditions such as income and education.

It appears that these results are a first confirmation of the hypothesis of a strong association between poorer health and functional ability in later life and disadvantaged conditions in early childhood and of the individuals' parents. More research using this and other data sources should be undertaken to shed more light on this issue.

Because multi-generational living arrangements are still the norm in Mexico, informal care plays a crucial role with respect to the health status of the elderly and their demand for services. However, as a result of these changes, a likely decrease in availability of informal care in the future highlights the importance of detailed information on health needs of the older population and how these needs will change in the future. In addition, it is necessary to further investigate the overall inequalities that the older population is facing, as well as future demands they will generate in terms both formal and informal support in order to generate informed strategies and policies to cater for their current and future needs.

Regarding the epidemiological transition the key determinant resulting from the before mentioned public health policies has been a remarkable transformation of the main causes of death and the prevalence of different illnesses or diseases from communicable diseases to non-communicable chronic diseases. By the year 2000, the five main causes of death were cardiovascular diseases, diabetes complications, cancer (malignant neoplasm), chronic respiratory diseases, and digestive tract diseases.

More recently, accidents have also become one of the main causes of death representing almost 8% of all cases. It is important to note that for the age groups 1-4, 5-14, and 15-29, accidents are the leading cause of death, with accidents caused by motor vehicles forming almost 50% of total accidents. A special case is the group of men 35-44 years old where accidents represent 20% of all deaths

As with most Latin American countries, Mexico is experiencing what experts call a "mixed" epidemiological transition with increasing prevalence of chronic diseases and a marked decrease in communicable diseases in some areas, while still suffering from moderate or high incidence of the latter in some regions of the country. As mentioned before, these differences among states/regions in the country and between more urban and rural areas are mainly due to lags in economic growth and marked inequalities in socio-economic development.

According to Palloni et al. (2002) alongside the fact that neither Mexico nor any other country in Latin America has institutional contexts –whether public or

private—that may respond to the changing social and healthcare demands from an elderly population, for most countries in the region a highly compressed aging process will take place in the midst of weak economies, changing intergenerational relations, and constricting access to medical and health care.

Services available for the older population in Mexico are scarce and scattered among the different institutions that provide them. In terms of health services and health care provision, the older population have to access health services as any other (age) group of the population, through the Mexican Health System. On the other hand, taking as a reference the World Health Organisation's definition of long-term care as the institutional or home-based activities that are either formally or informally provided for those not fully capable of self-care on a long-term basis, either by formal or informal caregivers, and including a wide array of services, we can say that these services in Mexico are mostly informally provided by family and close friends (World Health Organization, 2002).

There are scarce government provided services and some private (for profit and not-for-profit) institutions offer some services such as day-care and institutionalisation for those who cannot take care of themselves and have no one to take care of them. These health and social care services are described below.

Regarding health care provision for the older population, they can access the health system as the rest of the population. Since its creation, the Mexican Health System has been highly segmented. Health services and users are divided according to the health institution that provides the service. There are three main providers:

- a) Social security institutions,
- b) Public services offered by the Ministry of Health, and
- c) Private sector.

The three sectors work independently and parallel to each other and they are all financed through different mechanisms. The largest differences can be observed between the social security institutions and the benefits received by individuals affiliated to them, and the rest of the population.

Table 2.1 Main characteristics of the Mexican Health System

Sector/ Institution	Percentage population served	Group of population served	Funding/ Finance scheme	Services provided
Ministry of Health at federal and state-level	Approximately 40% of total population	Un-insured	Public funds from general taxes. Some public funds from the states.	Ambulatory care at community health centres throughout the country, second and third level hospital and specialized interventions at general and specialized hospitals.
Social Security Institutions: IMSS	Between 35% and 40%	Insured given their formal employment status, through the company they work in.	Three-way funding scheme: a) public funds from general taxes, b) fee from workers/employees, c) fee from employers A second option of voluntary affiliation irrespective of working status to either a health services- only scheme or a full-benefit scheme was recently implemented. It now represents approximately 5% of all insured.	The IMSS has a package of coverage schemes the most important of which are: a) sickness and maternity insurance, b) disability, unemployment, old age, and death insurance, c) labour risks insurance, and d) day care centres. Ambulatory care clinics, specialization clinics and hospitals.
Social Security Institutions: ISSSTE	Approximately 10% of the population (10 million workers and their families)	insured given their employment in federal/state government institutions.	Three-way funding scheme: employer, employee, and public funds from general taxes. Government as employer provides this fee and the public funds percentage of the fee, the rest is provided by the employee.	Package of medical insurance, disability, old age and unemployment schemes.
Private sector	Between 5- 10%	Those with no social security or public insurance (users of private consultant services) and those with private insurance schemes.	Out-of-pocket payments, health insurance policies for major interventions and ambulatory care based on co-payments.	Mainly specialist consultant and hospital services.

Source: Lopez-Ortega et al (2007)

Just as health services are provided to those affiliated to a social security institution through their formal employment status, eligibility for pensions and retirement benefits will depend on past participation in formal employment. The population not affiliated to any of the social security institutions have access to health care provided by the Ministry of Health, and for those who can afford it, through direct out-of-pocket payments to private services providers.

One of the main concerns in terms of health and social indicators for the future is the extent of insurance of the Mexican population. Because affiliation to one of the social security institutions is conditional on having formal employment, current economic conditions where a large percentage of the economically active population is working in the informal sector are causing increasing differences and disparities between the insured and the uninsured.

According to the National Health Survey 2000, barely 40% of the population had access to some social and/or health insurance mechanism. With only 1% of total population affiliated to private insurance mechanisms, the survey showed almost 60% of the population had no social or health insurance (Olaiz G et al., 2003).

Geriatric care and medical specialisation in geriatrics and gerontology are very young in Mexico. The first specialisation courses were created in the mid 1980s, first as Masters Programmes in geriatrics and later as medical specialisation⁴.

The number of medical doctors specialised in geriatrics is still very low and clearly insufficient. The fact that there are few formal geriatric services and a scarcity of geriatric doctors creates challenges to the provision of adequate care for the older population in the future.

It is clear then that access to health care for the older population is not easy and will largely depend on their social security affiliation, where they live, and their socioeconomic background. As mentioned before, access can be particularly difficult for those living in rural areas and especially for second and third level services which can be practically inaccessible.

As for other types of services, mainly what is known as community care and long-term institutional care, these are highly limited. Regarding government institutions, the Social Development Ministry, through different agencies, provides some services to the elderly uninsured population, mainly recreational activities, prevention and self-care information programmes, etc. In addition, the National Institute of Older Adults, INAPAM was created in 1979 to protect and support the population of people 60 years and older.

With the changing and growing needs of the older population, and in an effort to improve or generate new policies for the older adults, in 2002 the Institute ceased to be an independent governmental institution and is now part of the Social Development Ministry⁵. Each State in Mexico has a local representation of the Institute and all municipalities are also required to have a local office in charge of implementing all programmes and strategies of the Institute.

⁴ In 1986 a Regional ISSSTE hospital (Hospital Regional Adolfo Lopez Mateos) in Mexico City led by Dr. Rosalía Rodríguez, and the University of the State of Nuevo Leon created, simultaneously, the first programmes in medical gerontology. In 1993, Dr. Gutierrez-Robledo created the first university programme for Geriatric specialisation at the National Autonomous University of Mexico, UNAM (Universidad Nacional Autonoma de Mexico) medical school. It is considered that thanks to Dr. Gutierrez Robledo, Geriatrics as a specialisation is formally initiated in Mexico at the National Institute of Medical Sciences "Salvador Zubiran" INNSZ in Mexico City in 1994. Later, he founded the Geriatric Assessment Unit at INNSZ (Leal Mora et al. 2006), which to date is still one of the few institutions in the country to provide comprehensive geriatric care.

⁵ Further information can be found at: www.inapam.gob.mx

The main strategies provided by INAPAM are: a benefits and discount card for people 60 years and older; health education seminars and workshops; health control card; as well as training, recreational, and leisure activities. All these usually take place at INAPAM's cultural and community centres where older adults can attend all the services for free. In addition, INAPAM has few Integral-attention centres which specialise in geriatric services, acupuncture, vision, and audition medical services, lab tests, among others. There are 5 centres in Mexico City and some states offer different services according to their financial and human resources capabilities. However, these services are clearly oriented to those who are still in good health and functional conditions and are insufficient even at the current potential demand of adults 60 years and older.

As growing awareness of the increasing ageing population, the additional vulnerability of this group in Mexico given locality of residence, socioeconomic conditions, and the fact that less than a third of adults 70 years and older have a pension or social security benefits, has led to the launch recently of three strategies, two at national level and one in Mexico City in order to try to alleviate some of these disadvantages.

The first initiative at national level was launched by the Ministry of Social Development through two strategies. The first one is known as *Setenta y Mas* or Seventy and more. Its objectives are to provide economic support, social participation activities and services for older adults 70 years and older in localities of up to 30,000 people. The amount of the support is \$500 Mexican Pesos (approximately 35 US Dollars at current exchange rate) and diverse activities are organised by the local authorities.

The second strategy of the Ministry of Social Development is operated through a new component for older adults included in the *Oportunidades* programme since 2006. *Oportunidades*⁶ is a comprehensive programme for those living in extreme poverty and with the highest levels of under-nutrition, communicable diseases and school dropout. The programme has been operating since 1994. The monetary support for older adults was incorporated for in 2006 for adults 70 years and older living with a family that is already a beneficiary of *Oportunidades*, that is, that are

⁶ *Oportunidades* supports families through three components: health, nutrition, and education, and operates based on the co-responsibility of those selected as beneficiaries of the programme. Thus, in order to receive any of the supports, beneficiaries have to either attend school, health services, as well as prevention and health education talks, depending on the type of support, age and sex of the beneficiaries. It is coordinated at federal level by the Ministry of Social Development and operated at state level by the Ministries' offices in each state. Further information can be found at: www.sedesol.gob.mx and www.oportunidades.gob.mx

in highly disadvantaged conditions and living in poverty. The amount of the support started at \$260 Mexican pesos in 2006 and increased yearly up to \$290 Mexican pesos for 2009 (approximately 20 and 25 US dollars respectively at current exchange rates). As co-responsibility for receiving the monetary support, the beneficiaries have to attend a medical consultation twice a year.

The second initiative at national level is included within the System of Social Protection in Health, SPSS. The SPSS was created during the 2000-2006 administration in order to provide an alternative scheme of public and universal insurance for those who had no access to health services⁷. The system is operated through the *Seguro Popular* which is coordinated at the federal level and operated by each state through their Ministry of Health. The first Catalogue of Medical Benefits for the period 2002-2003 included 78 interventions selected following studies of burden of disease and morbidity incidence and prevalence. These interventions have increased yearly and now include 255 interventions and specific health services. In the beginning of the programme, most interventions were focused on newborn, young children and young adults between the ages of 20 and 59 years, the last increase in interventions within the Basic Package of Services includes 16 actions for men and women 60 years and older that cover diverse areas such as oral health, prevention and control of tuberculosis, and diagnosis of diabetes, hypertension and obesity (Secretaría de Salud, 2008).

The initiative in Mexico City was established by the Government of the City (Gobierno del Distrito Federal) who created the Food Support, Medical Attention, and Free Medicines Programme. The programme started in March 2001 giving an alimentary pension to 150,000 residents 70 years and older. For 2008 the number of beneficiaries reached 422,500 and the target for 2009 is of 470,000 beneficiaries, an estimated 96% coverage of all older adults 70 years and older who reside in Mexico City. The alimentary pension is provided through an electronic card that can be used in most commercial establishments in the City. The amount of the pension started at \$600 Mexican pesos a month in 2001 and has fixed at \$822 pesos for the fiscal year 2009 (approximately 55 and 63 US Dollars at current exchange rates).

⁷ The main objective of the initiative was to insure access to health services provided by public institutions independent of their socioeconomic conditions and their current health status. In addition it intends to decrease or eliminate out-of-pocket payments at the moment of receiving the services by establishing an annual pre-payment fee per family covered. The two lowest income deciles of the population are exempt of paying the family annual fee. Further information can be found at: www.seguro-popular.salud.gob.mx

In addition, the initiative includes medical visits for older adults 70 years and older who are physically unable to attend a clinic or health care centre. The main objectives of the visits are to identify any risks at the household, the existence or not of proper care, and if needed, to provide training to the family in how to provide better care for the older person. Also, it aims to identify medical conditions and when needed refer the person to medical services, informing the family members of this need (Gobierno del Distrito Federal, 2009).

In order to evaluate the impact of the programme, the programme undertook in 2008 the Survey on the Perceptions of the Benefits and Evaluation of the Alimentary Pension. However, data published to date only includes broad information on number of beneficiaries, their profile regarding age, sex, household type, among other topics that do not reflect the real impact on the population's wellbeing or comparison of conditions before and after the programme. It is hoped that in the future the Programme includes in addition impact and economic evaluations and it will be possible to see the feasibility of replicating this experience in other states.

Given that these interventions for older adults were recently incorporated into broader government policies aimed at fighting poverty, it is too soon to know what their impact has been and evaluation strategies should be incorporated now to achieve this end. However, they are recognised as a first effort to alleviate some of the main inequalities that render this population group in an especially vulnerable situation.

In addition to publicly provided services, the profit and not-for-profit private sector has developed some services. These sectors have concentrated in day-centres or institutions called *asilos* or asylums. Day-centres usually offer recreational activities, health care and health promotion talks and mainly serve as meeting points. On the other hand, *asilos* are institutions where older adults who have no relatives or no one to take care of them can go and live. In general they only admit older adults who are still in good health, offer food and board, carers, and a medical doctor in-site. Services provided by for-profit institutions are only accessible to a very small percentage of the population that can pay for them.

Unfortunately, neither health nor social development institutions have made the effort to regulate or generate norms that govern these institutions, most of the ones that are known are characterised by their small and informal nature and there is no real way to know if they are covering the standards required for appropriate

social care for the people that live in them. Given that there are no national or at least state-level directories of existing institutions, the very limited information that is now available for some of them is through government agencies or large voluntary organisations if they receive funds from them and are therefore registered. An example of this are a small number of institutions that receive funding from the Institute of Assistance and Social Integration (Instituto de Asistencia e Integración Social) created by the Government of Mexico City to support vulnerable groups in the City in 2001. The latest report published is from 2006 where out of the 27 institutions supported five were dedicated to older adults. However, the only information published on the institutions regards the name and address of the institution, their target population, broad description of their activities and the amount of support received.

A similar situation was found when consulting the information available at CEMEFI, Centro Mexicano para la Filantropía (Mexican Centre for Philanthropy) defined by its creator as a civil society support organization. CEMEFI lists 11,069 institutions as registered with them, covering a wide array of issues covered by them from animal protection, to sports and recreation, rehabilitation, training and employment, etc. Of this total, 322 organisations appear to be dedicated to adults 60 years and older (search term), but the only information published is general data as their name, address, contact details, and broad field of action or main activity. However, only 85 are registered in the National Social Organisations Directory of the Internal Affairs Ministry. Similarly, in consulting this Directory, the only information available is the name of the organisation, address, and contact details. Unfortunately, there is no information that says if they conduct any monitoring or audit of the data provided by the organisations, if any of the organisations are visited in order to confirm their status and evaluate the services they are providing, or about the people they are providing these services for and their wellbeing.

This very short review of existing options providing care services for older adults by the non-profit and for-profit private services clearly shows that what can be described as “formal” private services are a gray area lacking regulation, lacking information on everything from the services they provide, their quality and the impact they have. It is clear also that great efforts should be made in order to generate a directory of existing institutions and from there to undertake in-depth evaluations of their services and their impact on the wellbeing of the population they are serving.

Given the current scarce government integral strategies for health and social care for the elderly in Mexico and the little information available on private (for-profit and not-for-profit) institutions the type and quality of the services they provide, and on the population they are serving, it is clear that health, social security, and social development ministries who have historically tried to compensate with alternative or palliative strategies to provide services for the older population are largely unprepared to cater for the needs of the growing elderly population.

In addition, a rapidly ageing population and the absence of formal support services for the elderly has left informal caregivers, mostly women, to continue with their main responsibility in the provision of household care activities through the life cycle, from early childhood care and family health care, to health and long-term care services for the elderly.

Although this lack of strategies for the older population has not yet created huge crises in terms of the provision and financing of services, presumably in a large part due to the support of the family and social networks of the elderly, a large increase in their numbers will at least cause a large additional burden on households and on the available services.

Currently, public services provided for the older population don't have the knowledge on health and social care services that could be provided according to their future needs. In addition, there is no clear or comprehensive information on services provided by the private sector, much less their quality and efficiency, or the impact they have in the wellbeing of this population group.

In this context, research that generates new knowledge which can be used in the planning of new strategies and policies is greatly needed.

Chapter 3 Conceptualisation and measurement of health, frailty, and disability

3.1 Introduction

From Gompertz' work in the 1820s and his law of mortality⁸, to the generation of key theories of population health and mortality, and more current calculations of number of years lived with or without disability, it is clear that there has been a steadily increasing interest in social and scientific research to try and identify the processes through which population transits through their life course.

Recognising that health status means much more than being free of illness or death, large efforts were made in order to define and measure different health states through the life cycle, and in particular in older age, especially those years lived with disability or in a frail condition.

Thus, it appears that as periodical, sound statistics and surveys became available, methods to calculate population health evolved from simple but fundamental estimations of total population by counting births, deaths, and migration, to the creation of life tables and more recent complex summary measures of population health. With time, measures included the impact of social and economic factors, early childhood conditions, and risk behaviours as important markers of health in later life.

As noted in the background chapter, Mexico is undergoing a rapid transition regarding its demographic and epidemiologic conditions. A rapidly decreasing fertility rate since the 1970s paired with equally relevant decreasing mortality rates both at very early and older ages, and a progressive increase in life expectancy brought about an equally rapid process of population ageing which is expected to reach its maximum growth rate in the first three decades of this century.

These changes have also had an impact on the overall health status of the population. Particularly, the main causes of mortality have shifted from communicable and infectious diseases to non-communicable chronic diseases such as cardiovascular disease, diabetes, and obstructive pulmonary chronic disease, among others. In addition, within the younger working age population there has been a significant increase in accidents and violence related deaths and long-term (life) disabilities.

⁸ The law establishes that mortality rates increase at an exponential rate as age increases

In this context, it is clear that a more comprehensive knowledge of the health, functional ability, and frailty status of the ageing population in Mexico is needed not only given its importance as an input for future policies on healthy ageing that can cater to the specific needs of the older population, but also because these issues represent key indicators of overall wellbeing of the population.

This chapter introduces the main theories behind population health and mortality, as well as the conceptualisation of disability and frailty. This is followed by a review of previous empirical work on mortality, disability, and frailty in samples from different countries and the work undertaken in Mexico on these topics. This chapter presents these concepts as an introduction to part of the empirical work undertaken in the thesis and developed in the following chapters.

3.2 Conceptualisation of health, disability, and frailty

As research developed, different theories or hypotheses about the future progression of health states in old age and how to estimate health status and its relation with different variables were generated. For example, the relation between mortality and morbidity encouraged interest in further measures of life expectancy, especially those that combined this indicator with other health indicators such as disability as well as the current expansion of what are now defined as summary measures of population health.

Three main theories or hypotheses of the pathways of mortality and morbidity, and the relation between life expectancy and health status have been developed. The first hypothesis was put forth by Gruenberg (1977) who established that although technologic advances and preventive strategies had diminished the occurrence and prevalence rate of some illnesses, they caused an increased average of duration of conditions with complications that were only postponed to later ages in life (p. 18). In his seminal work, Gruenberg clearly saw increased life expectancy not necessarily as the best option, but very likely as a period lived with high disability and complications. He notes:

"Now that we recognize that our life-saving technology of the past four decades has outstripped our health-preserving technology and that the net effect has been to worsen the people's health, we must begin the search for preventable causes of the chronic illnesses which we have been extending. Epidemiologists must play a key role in finding these causes, but without the application of social pressures in that direction, few will take up the opportunity. For a period, at least, health saving must take precedence over life saving. And we will not move forward in enhancing

health until we make the prevention of nonfatal chronic illness our top research priority" (p. 22).

This hypothesis was further developed by Olshansky (1991) who named this theory the *expansion of morbidity*. That is, he states that increases in longevity will go hand in hand with an increasing number of years spent in poor health.

The second hypothesis around the course of morbidity and mortality is that of a compression of morbidity and was generated by Fries (1983) who argued that as population ageing develops, morbidity and disability will decline and increasingly see an onset at later ages while life expectancy would not go over 85 years. Thus, morbidity starts in later age and becomes compressed into a shorter duration of time before death.

Proposing an intermediate scenario Manton and collaborators draw from earlier hypotheses to explore the relation between morbidity and mortality as life expectancy increases. They introduce a hypothesis of dynamic equilibrium (Manton, 1982; Manton, Corder, and Stallard, 1997). Recognising relations between ageing and mortality as a complex phenomenon which in order to be explored must be viewed as multi-dimensional processes where chronic degenerative diseases are a main determining factor. The main concept behind their hypothesis is that if incidence of disease remains unchanged, mortality reductions that lead to increasing life expectancy can only occur by increasing the duration of the disease and its prevalence.

In addition, their hypothesis implies that the severity and rate of progression of disease are directly related to mortality so that in view of mortality reductions there will also be a reduction in the progression (or slower progression) of morbidity and severity of disease. Thus, under this concept the time spent with high morbidity or serious severity of disease will tend to decrease.

A major advance in these theories and their application was the introduction of disability as an indicator of both the severity of morbid states and as an indicator of the quality of years lived. Additionally, it allowed the generation of methods for analysing morbidity and mortality of the total population by partitioning years of life into those with and without disability, leading to the development of indicators of health expectancy, disability free life expectancy, and healthy/active life expectancy as population health indicators with which to further test these scenarios (Robine, Romieu, and Cambois, 1999; Robine and Jagger, 2005).

Building on this, further research concentrated on summary measures of population health. Thus, applied work focused on changes in burden of disease, changes in functional limitations and/or disability levels (mainly measured by ability to perform Activities of Daily Living, ADLs and Instrumental Activities of Daily Living, IADLs), and generated measures such as active life expectancy, ALE, disability free life expectancy, DFLE, disability-adjusted life years, DALYs among others (Murray, Salomon, and Mathers, 2000).

Important work has been developed by the Réseau Espérance de Vie en Santé, REVES network who proposed a classification system of health expectancies based on the concepts of the international classifications of diseases and their consequences, and on those of perceived health and adjustments to health (Robine, Romieu, and Cambois, 1999). This international network was established in 1989 "to promote the use of health expectancy indicators and improve their comparability" (Robine, 2002).

Since then, research incorporating measures of ability and functional limitations into health indicators has increased and disability and frailty recognised as crucial parts of the ageing process. At the same time, national health and disability surveys⁹, many times longitudinal, started to become an integral part of different countries' regular statistics.

3.2.1 Measuring health, disability, and frailty

The growing importance of discussing the relations between ageing, chronic illness, and disability in a broader context brought about an increasing number of empirical studies in a wide array of countries. As research in health services and health policy continued to develop, researchers looked for indicators that reflected more precisely the health and disability status of different population groups.

In its first stages, analyses of disability status and its relation to old age concentrated on what is defined as Activities of Daily Living, ADLs and Instrumental Activities of Daily Living, IADLs.

The concept of ADLs was first proposed by Katz and colleagues (1963) as a grouping of functions that are often disrupted by different events and can therefore be useful benchmarks for testing the effects of rehabilitation in patients (initially with post-stroke patients). They generated a scale to measure ability to perform

⁹ For a comprehensive summary of selected national surveys on health and disability consult: Gaudex, C and Lafortune, G. 2000. *An Inventory of Health and Disability-Related Surveys in OECD countries*, OECD DEELSA/ELSA/WD(2000)5.

ADLs. The concept behind the Katz Index is that human functioning occurs in a particular order with the most complex functions lost first. In order to measure this, his Index of Independence in ADLs includes six activities scored as: independence (1) and with dependence (0). A score of 6 indicates full function, a score of 4 for moderate impairment, while a score of 2 or less indicates severe functional impairment.

The Katz Index has been noted as one of the most appropriate instruments to assess functional status and independence as well as one of the best practices in nursing care of older adults (Shelkey and Wallace, 1998).

Other instruments for the measurement of functionality that have been widely used include the Barthel Index for Functional Evaluation created by Mahoney and Barthel in 1965 (McDowell, 2006), and the Rosow and Breslau Scale (Rosow and Breslau, 1966).

The Barthel Index was originally generated to evaluate the level of functional dependence on ADLs for institutionalised chronically ill patients and patients with paralysis, scoring their ability to perform 10 different activities, with values that go from 0-unable to 10- independent-fully able. Rosow and Breslau generated a Guttman-type scale to measure functional ability and health in older people. Since their creation, these scales have been widely used to assess patients with other conditions or to evaluate ability in ADLs in general population samples in several countries and settings.

Regarding Instrumental Activities of Daily Living, the first scale and most widely used is that of Lawton and Brody. This scale is composed of eight dimensions or main activities considered instrumental to independent living such as managing money, shopping, and food preparation, among others. In their view human behaviour varies in the degree of complexity required for functioning in different tasks. The levels go from the easy to the most complex levels of functional health (Lawton and Brody, 1969). Then, "the functioning human being may thus be assessed by measuring instruments designed to tap representative behaviour at each level and within the range of competence appropriate to the individual" (p.179).

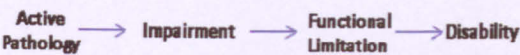
Instead of concentrating on basic daily activities, some measurement instruments have concentrated on the ability or not to carry out different physical activities. One of the more widely known frameworks is the one proposed by Nagi (1976). For Nagi, functional limitations imply restrictions in the ability to perform generic

physical and mental actions, whereas disability refers to difficulty or limitation in performing activities in any domain of life and is a function of the interaction of individuals and their social environment.

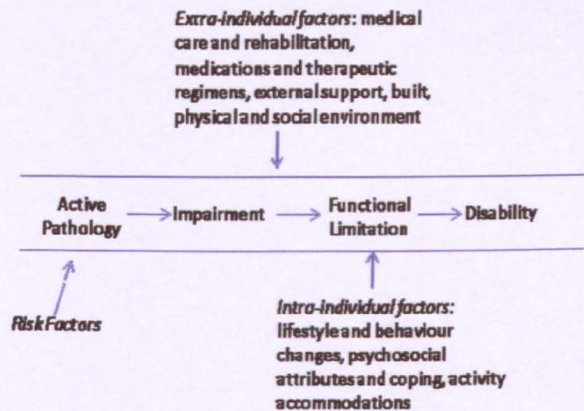
Nagi in addition developed a measurement instrument that includes tasks such as pushing large objects, stooping, crouching, kneeling, and reaching above one’s shoulders. Nagi’s model of disablement, adapted from the original source is presented in Figure 3.1. The model shows a pathway from acquiring an illness or disease or “active pathology” to different types of functional status. In this process, Nagi notes that not all impairments or functional limitations will rapidly transform into disability and in the same way, similar patterns of disability may result from different types of impairments and limitations in functional ability. This highlights the impact of individual and social aspects in the process and presents disability more as the limitation on people’s normal everyday activities due to illness or diseases.

Figure 3.1 Models of Disablement

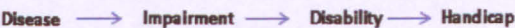
Nagi’s disablement model



Jette and Verbrugge’s model of The Disablement Process



International Classification of Impairments, Disabilities, and Handicaps (ICDH)



Another pioneer conceptual framework and implementation of disability which is widely used in different studies is that of Verbrugge and Jette (1994) who introduced the model of *The Disablement Process* to concentrate the attention on predisposing factors for disability, and introduced factors that can either speed up or slow down the pathway of disability. Their model takes the basic concepts used by Nagi and its definitions, but in addition categorised different sub-dimensions of social factors. Thus, the disablement process is a dynamic model that takes into account "intra- and extra-individual factors" such as demographic background, risk factors, chronic diseases, functional abilities, and social components such as recreational activities and social participation. These concepts are posited to modify the main disablement pathways leading from active pathology to disability. The disablement process model adapted from the original source is presented in Figure 3.1.

Within International Organisations, one of the major efforts in terms of generating more comprehensive and extensive measures of disablement was the World Health Organisation's International Classification of Impairments, Disabilities, and Handicaps, ICIDH (World Health Organisation, 1980). The aim of the Classification was to provide countries with a tool to assess the consequences of disease and the process of disability. As one can see in Figure 3.1, the disablement model proposed by the WHO also includes a linear progression or pathway from disease or active pathology to different functional difficulties. It differs in that whereas disability is defined in terms of the loss of ability or capacity to carry out activities in a normal manner as a result of some impairment, they introduce the concept of handicap defined as disadvantages due to disability or impairment due to social factors such as age, sex and socio-cultural factors.

Since their first ICIDH manual, a working group at WHO has constantly reviewed the classification's conceptual framework and conducted field trials which generated further classifications such as the ICIDH-Beta2 and the International Classification of Functioning, Disability and Health, ICF (World Health Organisation, 1999).

Further, these classifications were subject to different trials and in 2001 a new classification was presented. The latest ICF frameworks changed the way disability is understood by presenting it not as a problem of a minority group or of people with visible impairments, but as a way people live with their health conditions, and how this can be improved to achieve a productive and fulfilling life. Notably, it includes as a major component contextual factors or social aspects of disability as a

mechanism to document the impact of the social and physical environment on a person's functioning (World Health Organisation, 2001).

In sum, disability is recognised as a central concept in defining overall health of older adults when health problems cause difficulties in household and personal care as well as in their participation in diverse activities such as work, social, and recreational events. The disablement models have been widely used in areas such as physical therapy to define the consequences of disease and injury as well as in a wide number of empirical studies. However, one of the main challenges that remains is the achievement of agreement on the causal links between the different concepts that constitute the pathway to disability, as well as the acceptance that the pathway is not necessarily a linear one but possibly circular or multidirectional. In addition, there is no consensus on what are the best operationalisation of disability, and the methods for its measurement.

The second concept that will be introduced is that of Frailty. Its definition and estimation emerged as a more comprehensive way to describe an older population's situation by going further than morbidity, mortality, and disability indicators. As a result, multiple studies have defined frailty status as one of the best ways to evaluate the health status of older adults because it provides objective data that may indicate future decline or improvement in health status.

In spite of the vast literature and empirical work generated around the subject of frailty, it has proved difficult to agree a universal definition and measurement for frailty or frail status. In consequence a wide range of definitions and methods applied to different population data are found within the empirical work in the subject. However, it seems that the main efforts have concentrated on generating indicators of frailty or Frailty Indexes within different local contexts. There are two main estimation methods have been developed.

One of the first efforts developed to measure frailty is by is that of Fried and colleagues (2001) who developed and applied a phenotype of frailty in older adults using data from the Cardiovascular Health Study, USA in a sample of men and women 65 years and older. They introduce a frailty phenotype or operational definition to the clinical syndrome of frailty. Frailty is defined as a clinical syndrome in which three or more of the following criteria are present: unintentional weight loss (10 lbs in past year), self-reported exhaustion, weakness (grip strength), slow walking speed, and low physical activity. Those with one or two are labelled as pre-fail.

In their first study, results showed that overall prevalence of frailty increased with age and was greater in women than in men, it was also found to be highly associated with being African American, having lower education and income, poorer health, and having higher rates of chronic diseases and disability. In addition, findings support the hypothesis that frailty has an a strong independent predictive validity for mortality, disability, and hospitalisation, independent of clinical and subclinical diseases.

An additional operationalisation of frailty and extensive work on generating a frailty index and its application for different samples of older Canadians has been carried out by Rockwood, Mitnitski and colleagues (Mitnitski et al., 2002b; Mitnitski et al., 2002a; Mitnitski, Song, and Rockwood, 2004; Mitnitski et al., 2005; Mitnitski and Rockwood, 2006). In their work, they propose a means of summarising health status and its variability by counting the deficits (symptoms, illnesses, etc.) present in individuals and inferring relative fitness or frailty on that basis. Their main work includes the 7-point Clinical Frailty Scale. These methods were further applied for other samples from the Canadian older population (Jones, Song, and Rockwood, 2004; Jones et al., 2005).

The scale was developed and first applied to a sample of older patients from the Canadian Study of Health and Aging (CSHA), in order to construct a frailty index for this population group. The frailty index is a count of 70 symptoms, deficits, etc. Items included are the presence and severity of current diseases, ability in the activities of daily living, physical and neurological signs from clinical examination, impairments, among others.

In addition, studies for China (Googins et al., 2005) and Connecticut (Searle et al., 2008) replicate the original studies and apply this methodology to construct a frailty index for their samples of study and estimate its relation to different factors such as sex, age, and survival.

As noted in several of these studies applying the methods and generating this frailty index they share some common results that are worth citing. For example, it appears from the Canadian studies that it is the proportion of the total deficits that make up the frailty index which are strongly related to death, but not the nature or type of deficit. Also, even when using different samples (within Canada and the studies in other countries) the index is higher in women than in men, and is highly correlated with survival. These findings have led this group of researchers to

consider the frailty index as a sound group and individual-level indicator of health and wellbeing (Mitnitski et al., 2002b).

Finally, an example from the USA based on the work of Mitniski, Rockwood and colleagues is the work by Kulminski and colleagues (2007) who generated a cumulative index of age-associated disorders defined as deficits. Using the National Long-term Care Survey they compare individuals who died before age 75 years, those who died at 85 years, and long-living individuals aged 85 years and older. According to their results, despite the difference in age profiles, the frailty index shows nearly identical frequency patterns. That is, distributions at death seem to be basically age-insensitive showing that it is accumulation of deficits or conditions and not necessarily age which is most relevant in determining old age mortality.

Even when studies have reported how the concepts of morbidity-frailty-disability-mortality are related and clearly interact in the ageing process, pinning down the relations between them has not proved to be simple. Equally, it is clear that the ageing process does not follow a clear and timed pattern, and has lead to a "dynamic" view of the role frailty and disability play in later life.

As one of the main researchers in the area notes:

"Over a lifetime, chronic problems can simply accumulate in number, operating independently of each other, or they can interact synergistically to cause symptoms and increase the risk of further health problems. Morbidity influences physical and social functioning, happiness and anxiety, across days and years of life. Disability too, is dynamic; often it is temporary but occasionally permanent. Individual dynamics of morbidity aggregate into population health statistics which shift over time in conjunction with widespread changes in individuals' health experiences" (Vebrugge, 1989).

3.3 *Previous empirical work*

3.3.1 General work on disability and frailty

Applied work of summary measures of population health such as ALE, DFLE, DALYs, and disability-adjusted life expectancy DALE has been carried out extensively in several developed countries. These studies have included total population, as well as specific population groups according to their age group or with specific conditions or diseases.

A major aim of the studies appears to be the exploration of individual's health according to these measurements, to estimate within group/country differences in onset of diseases and progression of disability, as well as some cross-country comparisons. These studies have been generated mainly within European countries, and studies of this kind are scarce in most developing countries where mortality, morbidity, and life expectancy continue to be the main health indicators used in research and policy planning.

Not ignoring the relevance of summary measures of population health and the large literature of applied studies using them, the main objective of this study is exploring disability and frailty in a sample of the ageing Mexican population and therefore, the review presented here only includes studies on these two topics¹⁰.

Disability in old age has been of increasing interest for researchers who see this indicator as an important key marker of population health, by going further than morbidity estimations and incorporating the impact disability due to diseases and symptoms has on their daily activities. As a result, many studies have been generated which include disability and the effect of different factors on disability for older population groups worldwide. This review presents some of the most recent.

The main focus of studies has been for example on socio-demographic characteristics (differences) in the onset and progression to disability (Grundy and Glaser, 2000), on mobility-disability estimation (Melzer et al., 2004), on socio-

¹⁰ For example, extensive work for the UK can be found in the work of Jagger, C., Goyder, E., Clarke, M., Brouard, N. & Arthur, A. 2003. Active life expectancy in people with and without diabetes. *J Public Health Med*, 25, 42-6.; Jagger, C., Matthews, R., Matthews, F., Robinson, T., Robine, J. M. & Brayne, C. 2007. The burden of diseases on disability-free life expectancy in later life. *J Gerontol A Biol Sci Med Sci*, 62, 408-14.; Matthews, R. J., Smith, L. K., Hancock, R. M., Jagger, C. & Spiers, N. A. 2005. Socioeconomic factors associated with the onset of disability in older age: a longitudinal study of people aged 75 years and over. *Soc Sci Med*, 61, 1567-75.; Matthews, R. J., Jagger, C. & Hancock, R. M. 2006. Does socio-economic advantage lead to a longer, healthier old age? *Soc Sci Med*, 62, 2489-99. In other countries work includes among others, Spain: Sagardui-Villamor, J., Guallar-Castillón, P., García-Ferruelo, M., Banegas, J. R. & Rodríguez-Artalejo, F. 2005. Trends in Disability and Disability-Free Life Expectancy Among Elderly People in Spain: 1986-1999. *Journals of Gerontology Series A: Biological Sciences & Medical Sciences*, 60A, 1028-1034.; Australia: Mathers, C. D., Vos, E. T., Stevenson, C. E. & Begg, S. J. 2000. The Australian Burden of Disease Study: measuring the loss of health from diseases, injuries and risk factors. *Med J Aust*, 172, 592-6; Mathers, C. D., De Vos, E. T., Stevenson, C. E. & Begg, S. J. 2001. The burden of disease and injury in Australia. *Bull World Health Organ*, 79, 1076-84.; France: Cambois, E., Robine, J. M. & Hayward, M. D. 2001. Social inequalities in disability-free life expectancy in the French male population, 1980-1991. *Demography*, 38, 513-24. For the USA: Crimmins, E. M. 1981. The changing pattern of American mortality decline, 1940-77, and its implications for the future. *Population and Development Review*, 7. Crimmins, E., Saito, Y. & Ingegneri, D. 1989. Changes in Life Expectancy and Disability Free Life Expectancy in the US. *Population and Development Review* 15. CRIMMINS, E. M., SAITO, Y. & INEGNERI, D. 1997. Trends in disability-free life expectancy in the United States, 1970-1990. *Population and Development Review*, 23., and Manton, K. G. & Land, K. C. 2000. Active life expectancy estimates for the U.S. elderly population: a multidimensional continuous-mixture model of functional change applied to completed cohorts, 1982-1996. *Demography*, 37, 253-65. For European country comparisons: Robine, J. M. & Jagger, C. 2003. Creating a coherent set of indicators to monitor health across Europe: the Euro-REVES 2 project. *Eur J Public Health*, 13, 6-14.; Robine, J. M. & Jagger, C. 2005. The relationship between increasing life expectancy and healthy life expectancy. *Ageing Horizons*. Oxford Institute of Ageing, among many others.

demographic correlates of mobility disability (Melzer and Parahyba, 2004), among other issues.

In their study for the UK Grundy and Glaser measured severity of disability at baseline (1988) and follow-up (1994) and used logistic regression to analyse transitions in incidence and progression of disability. They found increased severity of disability and new incidence associated with lower SES, baseline self-rated health status, age, and gender, but no clear reasons for associations between disability and SES were found (Grundy and Glaser, 2000).

Using self-reported ability to walk a quarter of a mile (402m.) as reported in the English Longitudinal Study of Ageing, ELSA 2002 Melzer et al. (2004) assessed mobility disability for a middle-aged English population. They found the factors which at least doubled the odds of mobility disability in the middle-aged were chronic obstructive lung disease, angina, stroke, recently treated cancer, co-morbidity, lower limb and back pain, with 38% of mobility disability in this age group related to these last two conditions (Melzer et al., 2004).

A study undertaken in Brazil found through logistic regression analyses that the stronger markers associated with increased mobility disability prevalence were age, gender, lack of education and local income, with higher prevalence rates reported by women. In addition, rural residence was associated with reduced prevalence (Melzer and Parahyba, 2004).

Other studies have concentrated on the relationship between chronic diseases and disability. For example, work for the Netherlands found that older persons with low income had higher prevalence of ADL-disability, higher prevalence of impairments, and equal prevalence of chronic diseases, except for dementia and co-morbidity. They conclude that neither the prevalence of chronic disease, nor the association with disability could explain this (Bootsma-Van Der Wiel et al., 2005).

For Spain's non-institutionalised older population two studies found a high prevalence of disability among this group, and note this might be explained by a greater number of chronic diseases, a higher percentage of subjects with low educational level and a higher proportion of community-dwelling older persons than in Anglo-Saxon countries (Graciani et al., 2004; Li, 2005).

Different studies of predictors of transitions or trends in specific ADL/IADL disabilities have been also generated. Some examples from the USA include the work of Li (2005) who through hierarchical linear modelling examines the effects of psychosocial and health factors on the ADL disability trajectory of low-income frail

elders living in the community in Michigan. Findings show that being black, in the oldest age groups and living with no spouse or partner were the highest risk factors of disability in ADL and transitions to disability.

The work by Reynolds and Silverstein (2003) on the other hand, use a national sample of the ageing population (Study of Assets and Health Dynamics among the Oldest Old, AHEAD) to examine onset of disability of ADLs and IADLs; while Yang and George (2005) use the US National Institute of Aging Established Populations for Epidemiologic Studies of the Elderly (EPESE) to analyse potential relationships between function disability and depressive symptoms. Their results show that both stable disability and transition status are significantly related to change in depressive symptoms.

Further research has included combinations of scales and instruments in order to have more comprehensive measures of functional activity and limitations in the older population for a wide variety of countries.

Using a sample of non-institutionalised older adults in Madrid Valderama-Gama et al. (2002) determine prevalence of chronic diseases, disability in different activities, and their causes. Their results show that cerebral-vascular diseases, depression/anxiety disorders, and diabetes were the conditions most likely to be related to disability in old age, with osteoarthritis being reported as a major additional self-reported factor in disability.

Finally, Shibata, Sugisawa, and Watanabe (2001) address concepts, definitions, and measurements of functional capacity. They estimate distributions of functional capacity according to various indicators of ADLs and IADLs for a sample of community-dwelling Japanese using the Tokyo Metropolitan Institute of Gerontology (TMIG) Index of Competence, and active life expectancy. Using stepwise analysis for predictors of the score of the TMIG Index of Competence (functional status), their results confirm that not only physical variables but also social variables were significantly related to the maintenance of higher levels of functional capacity.

Work undertaken in Thailand present determined prevalence and severity of disability among the older population and compared disability-free life expectancy and self-care life expectancy among different age groups and between men and women (Jitapunkul and Kamolratanakul, 1994).

Another variant of studies have explored factors related to self-report of health and its relation to disability. Idler and Kasl (1995) analyse the mediating processes

involved in the association between self-ratings of health and mortality predictions. In another part of the study mentioned earlier, Shibata, Sugisawa, and Watanabe (2001) found that self-rated health was a significant predictor for functional capacity as assessed by the TMIG Index of Competence. This confirmed what other studies had found in that self-reported health has shown to be the next strongest predictor after age for the active life expectancy in the Japanese elderly. Self-rated health in these studies appears to be very useful not only as a valid and cost-effective substitute for objective health assessment and as a predictor of mortality, but also as a predictor of functional capacity at various levels.

There are also various analyses of the association between performance-based and self-reported measures of physical function such as the study for older women living in the community (Brach et al., 2002). A similar study determines the prognostic value of individual and combined approaches of self-reported functional status and performance-based functional status to predict functional status decline and mortality (Reuben et al., 2004).

Interestingly, there seem to be quite a few health related studies of Mexican Americans in the US in the past decades. Some of these include by Peek et al. (2003) who evaluate the Disablement Process Model using ADL disability as the outcome among a representative group of older Mexican American adults in the South Western United States. Keddle, Peek, and Markides (2005) examine the particular components of socioeconomic status that may be associated with functional limitation among older Mexican American men and women; while Ottenbacher et al. (2005) identify socio-demographic characteristics and health performance variables associated with frailty using a sample of 621 non-institutionalised Mexican Americans age 70+. Finally, Patel et al. (2006) compare the effects of morbid and co-morbid medical conditions on disability in older Mexican and Mexican American adults.

Others have concentrated on the prevalence and burden of different conditions and its self-reported status such as the work by Black, Ray, and Markides (1999) for diabetes in a group of older Mexican Americans in the US; and on the relationships between self-assessed health and physical IADL scores (Ailinger, 1989) for Hispanic older persons.

The first in-depth analyses of health status in the Latin American and Caribbean region were generated after the Health, Wellbeing, and Aging in Latin America and the Caribbean Study, SABE survey of main metropolitan areas in the region, from

which different studies and articles have been generated. Using SABE, (Reyes-Ortiz et al., 2006) use bivariate and multiple logistic regressions to compare rates of IADL and ADL difficulties, and examine socio-demographic and health correlates of IADL and ADL difficulties, finding interesting differences across cities.

The definition and estimation of frailty has become a more useful way to try to describe an elderly population's situation by going further than morbidity-mortality and disability indicators. As a result, many studies have incorporated its measurement, especially in relation to other conditions. In addition, many studies have explored the determinants of disability and frailty.

For the US, Fugate Woods et al. (2005) use simple indicators to define frailty, examine associations between demographic, medical history and behavioural risk factors, baseline and incident frailty (3 year follow-up), and determine associations between this frailty classification and future risks of death, hospitalisation, hip fracture, and ADL disability, using logistic regression models and Cox proportional hazard models.

Similarly for the US, Slivinske and Morawski (1996) generate a "Wellness Index" to assess well-being among the older population. This is a 79-item self-administered scale with six independent measures of well-being including physical health, morale, economic situation, limitations with ADL-IADLs, religiosity, social support or resources available to them. Principal component analysis methods were used in the analysis and their results suggested all subscales except economic resources could be combined to form a more comprehensive or "composite" measure of overall level functioning.

Other studies have gone further analysing frailty as an predictor of different outcomes such as becoming hospitalised, falling, function deterioration, and death (Fried et al., 2001).

In a wide number of studies, despite different measures being utilised, frailty has been shown to be a strong and independent predictor of such outcomes, a useful tool in the analysis of overall status of the older population and an identifier of more vulnerable groups (by undertaking these analyses for example by sex, locality of residence, socio-economic status, among others).

3.3.2 Work on disability and frailty in Mexico

Historically, studies on health of the older population in Mexico have been generated with data from National Health Surveys and official statistics on mortality, morbidity, prevalence of chronic diseases, etc.

In the mid 1990s an increased interest mainly by government institutions on the process of ageing and the older population in Mexico led to the first survey on ageing in 1994, the National Survey on Ageing. Unfortunately, since only a few studies have used this data set so no comprehensive information on this population group was available.

It was only with the generation of the Survey on Health, Well-Being, and Aging in Latin America and the Caribbean, 2000 (SABE) and the Mexican Health and Ageing survey 2001, 2003 (MHAS) that first hand information from samples of ageing Mexicans became available and further research was undertaken.

An important part of the pioneering research and applied work on ageing in Mexico has been carried out at the Geriatrics Assessment Unit of the Instituto Nacional de Nutrición y Ciencias Médicas Salvador Zubirán, one of the main Institutes of Health in Mexico. Some of the first reflections on the future of ageing populations and geriatric care in developing countries, including Mexico, can be found in the work of Gutiérrez-Robledo (2002).

Within the first studies on morbidity in Mexicans 60 years and older, is that of Ruiz-Arregui and Rivera-Márquez (1996). They use the 1998 National Health Survey to determine prevalence of different diseases and establish their relation with socio-demographic variables and daily activities. They found the prevalence of acute respiratory illnesses to be the highest, followed by hypertension, and diabetes. In addition, there was a high prevalence of difficulty to perform ADLs. While women reported higher risk of having acute respiratory illnesses, hypertension, and diabetes, they presented a lower risk for having difficulties with performing ADLs.

One of the first studies to go beyond mortality-morbidity analysis is the work by Ham Chande (2001). He presents a study of different health characteristics of growing old in Mexico. Results show that the prevalence rates for disability at age 60 are 10.5 for men and 18.7 for women, a difference that is maintained in all age groups for which this indicator was calculated. He also presents estimates of Active Life Expectancy (calculated based on the Sullivan method).

Results show that for a man aged 60, life expectancy is 20.7 years of which life expectancy with disability is expected to be 5.7 years. Regarding life and health expectancies (expected life with diagnosed or probable disease and disability data are aggregated to total life expectancies), patterns for the year 2000 show that a 60 year old woman has a life expectancy of 22.8 years, of which 18 will be spent with a diagnosed or probably suffered chronic disease. Using data from ENSA 2000, her expectations are of 14.5 years spent with a diagnosed chronic disease and 8.7 with a disability.

Due possibly to other pressing needs related to a “young” population, interest or concern for issues regarding the older population in Mexico is recent. Most research in this area has concentrated on mortality, morbidity (based on hospital discharge records, National Health Surveys and Ministry of Health statistics), as well as basic social and economic indicators of the older population (based on Census data and National Health Surveys).

The first summary measures of population health for the Mexico were made by Fundación Mexicana para la Salud, FUNSALUD (1994; 1997) who generated the first indicators of Burden of Disease measured by DALYs, effort that has been continued at the Ministry of Health.

Regarding the study of the older population and their current conditions, there are a few publications that have been relevant mainly for their innovation and visualisation of the actual and future burdens faced by this population group and the services provided to them.

The publication of a special volume of the National Public Health Institute’s journal dedicated to the health status, social and economic characteristics of the older population in Mexico (*Salud Pública de México*, 1996) marked the formal recognition of the need for research in health of the ageing population. In recent years, Ham Chande, (2003) and Salgado de Snyder and Wong (2003) published two books describing some conditions for this population group.

In a conceptual work using MHAS, put together a framework for the definition and analysis of ageing in Mexico taking into account several indicators of health status and risk factors in population 50 years and older. They generate a “typology of ageing” by classifying ageing in four types: ideal, active, habitual, and pathological. Indicators include chronic diseases, cognitive impairments, functional capacity, self-reported health status, consumption of alcohol and tobacco, as well as physical

activity. The Risk Factors indicator summarises individual behaviour regarding alcohol consumption, smoking, and sedentary behaviour.

The Health Indicator is constructed with four variables: diagnosis of chronic diseases, functional ability, cognitive impairment, and self-reported health. The main findings after constructing the typology corroborate the relation between ageing and each of the variables studied, but even more importantly, they indicate a typology that combines all variables in a single index.

To date only a few studies have used the MHAS to explore prevalence and determinants of functional dependence of older persons in Mexico. For example, Barrantes-Monge et al. (2007) generated a first study using multivariate logistic regressions. Functionality was measured using the Katz Index, while cognitive impairment was measured by classifying subjects using a total sum of scores from each of the tests included in the study. The scores are distributed in percentiles and corrected by educational attainment. Cognitive impairment was considered when the score fell under the 10th percentile (severe impairment). According to their results, prevalence of functional dependence was 24% for ADL and 23% for IADL. Those with more than one chronic disease, cerebral-vascular disease, cognitive impairment, and depression were found to be more likely to be more dependent.

On the other hand, Dorantes-Mendoza et al. (2007) identify factors associated with dependence for ADLs and IADLs using logistic regression. They find that those with dependence in performing ADLs and IADLs were more like to be in the oldest age group, women, have no formal education, and significantly higher number of chronic diseases. Regarding dependence in ADLs only, numbers were higher for those who were single or widowed, and poor self-reported health. On the other hand, the factors associated with dependence in IADLs were depression, vision problems, excessive pain,

On more specific issues, Mejía-Arango et al. (2007) used the MHAS to determine the prevalence of cognitive impairment in the older persons and its relation to socio-demographic and health factors. Their results show that seven percent of the population had cognitive impairment and nearly half of them had in addition some functional dependency. Regarding its association with other variables, cognitive impairment was not significantly associated with demographic or health factors, but cognitive impairment and functional dependency were associated with age, gender, marital status, depression, and some chronic diseases.

Also using MHAS, Barragán-Berlanga et al. (2007) explore the prevalence of and factors related to pain in population 50 years and older in Mexico. Prevalence of pain was more frequent in women, increasing with age, and had a negative relation with educational attainment. The main conditions associated with pain were arthritis, falls, hypertension, depression, lung problems, history of cancer, and difficulty in performing ADLs.

Other studies have focused on depression in older adults. Some examples include the work by Bello et al. (2005) who use data from the 2002-2003 National Assessment Performance Survey study the diagnosis and prevalence of depression in adults 18 years and older. Focusing on older adults, and using the MHAS, Ávila-Funes et al. (2006) explore the relation between depressive symptoms and functional status using analyses of differences between group means and logistic regression. In a different focus, Aguilar-Navarro et al. (2007) assess the validity and reliability of the questions included in MHAS to collect information on depression. This questionnaire was validated using the Diagnostic and Statistical Manual of Mental Disorders and the 15-item Geriatric Depression Scale and testing with patients at the Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán (May 2005 to March 2006).

It is interesting to note how even when the studies by Bello et al. (2005) and (Ávila-Funes et al. (2006) use different samples of the population and different statistical methods, some of their findings are similar. On average, depression has higher prevalence in women than in men, and in those with disadvantaged socio-economic conditions such as lower educational attainment; those with lower income, and the unemployed. Regarding the relation of depression and functional dependence, Ávila-Funes et al. (2006) found depressive symptoms to be a high risk factor of disability or loss in functional capacity, especially in IADLs. Finally, both studies note how it appears that depression is greatly under-diagnosed.

To my knowledge there is currently only one study that can be considered as comprehensive regarding the ageing population in Mexico. It is a two-year study (four interview periods) of a representative sample of the older population affiliated to the Social Security Institute, IMSS in Mexico City. In her study, Reyes Frausto (2001) explores health status and health services utilisation using descriptive statistics, logistic regression for the probability of using services, and multiple linear regression analysis for the intensity of use.

The results of the study show that women and the oldest persons had poorer self-perception of health and this was reflected in equally poor health conditions. Eighty-five percent of people in the sample had been diagnosed with at least one chronic disease, and the average number of diseases was 2.5, with high blood pressure, diabetes, gastritis, high cholesterol being the diseases with highest incidence. Still, the proportion of elderly subjects that had poor ADL and IADL scores was low, and thus, most of them could live independently. In addition, two fifths of the population were found to be depressed according to the Geriatric Depression Scale, with the frequency increasing with age, particularly in women. However, only one in ten had been clinically diagnosed, raising questions about the quality of the services provided.

Results from the logistic regression showed that utilisation of services in this sample (IMSS-Mexico City) seems to be determined by health status, severity of diseases, if the person attends special programmes for patients with chronic diseases, educational attainment, type of occupation, and coverage by other types of insurance. On the other hand, linear regression showed that the rate of utilisation was only explained by the presence of chronic diseases, their severity, and the level of education.

Finally, she uses the data from the four interviews to generate projections for 2000, 2010, 2020 of the prevalence of acute chronic diseases, IMSS health services utilisation, and annual costs of different services. However, projections are only generated with static scenarios (incidence of chronic disease continues at the same rate), or in which conditions grow parallel to population growth (the number of users per level or levels is expected to increase, in line with the population growth, pp. 163-165). The work could be improved by taking other factors and alternative scenarios (higher/lower prevalence) into account for validation and sensitivity analysis issues could be improved as different plausible scenarios should be taken into account.

3.4 Discussion

In the previous sections it was noted how two main conceptual and empirical frameworks that define and measure frailty have been utilised. One is a physiologically-based definition that generates a physical phenotype of weight loss, self-reported exhaustion, decreased grip strength, slow walking speed, and decreased physical activity (Fried et al. 2001). The second definition of frailty uses a more comprehensive approach incorporating not just physical measures of illness

or organ disease, but also considering psychosocial factors and vulnerability (i.e. self-rated health, social resources, economic factors, and cognition) as components or determinants of frailty status (Mitnitski et al., 2002b; Mitnitski et al., 2002a; Mitnitski, Song, and Rockwood, 2004; Mitnitski et al., 2005; Mitnitski and Rockwood, 2006).

In reviewing the empirical work in the areas of disability, the pathway to disability, functional limitations, and frailty, it is interesting to note how although there is wide interest from researchers and a large number of studies have been developed in the last decades, there is no universal consensus on their definition, on what should be measured and how, on the crucial measurements to include, etc.

Also, most indicators used appear to be solely concentrated on physiological conditions or measurements in their intent to describe overall status of the older people. Besides socioeconomic status, few studies seem to consider the relevance of a wide variety of social and demographic characteristics (other than age and gender) such as the social network and support received by family and friends, and of the satisfaction with this support as main determinants of the process of ageing, health, disability, and functional status.

Within this uncertainty, the idea of continuing to try and understand as much as possible what defines these concepts remains a constant idea in most studies. As a result, different countries have produced case studies for their older populations by constructing their own indicators, by using "classical" scales or measurement instruments, or adapting them to local conditions or the available data.

As a response to this uncertainty and the felt need of having more clear definitions of the different stages or conditions that characterise the pathway from good health to bad-worse health and eventually death, there has been increasing discussion by experts about the dynamics of such processes, existence or not of causality between frailty and disability, its direction, and determinants. Important steps have been taken by experts in order to try and explain or clear the confusion between frailty, co-morbidity, and disability in the hope that distinguishing them correctly could improve diagnostic accuracy, and the development of effective preventive strategies and treatments.

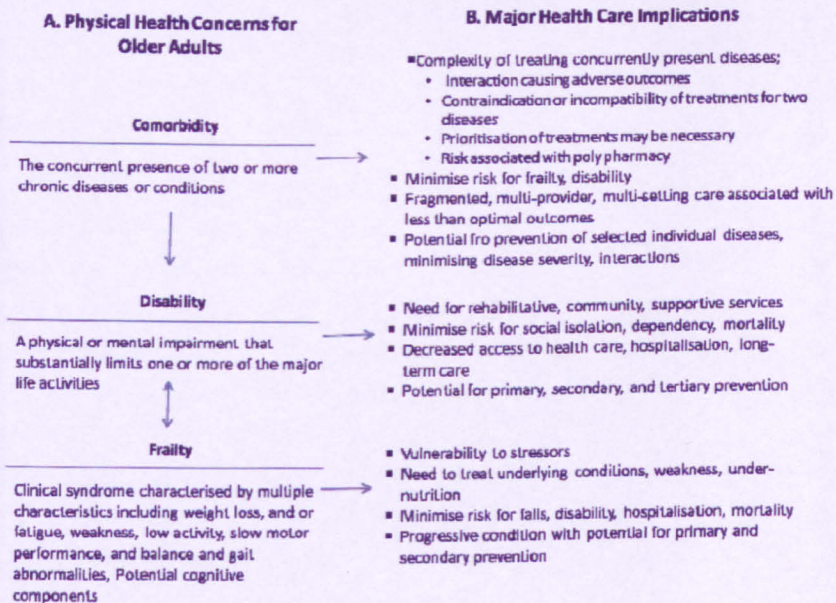
For Campbell and Buchner (1997) for example, while frailty and disability coexist with high frequency, disability is an indicator of loss of function while frailty indicated instability and risk of loss, or further loss of function. In their definition, disability may arise from a single catastrophic event in an otherwise robust

individual, for example, a stroke. After recovery minor, day-to-day fluctuations in function occur, but overall function is constant, the disability is stable, and the patient may otherwise be in good health.

On the other, they define *unstable disability* as a state which occurs when function fluctuates markedly with minor external events such as change in drug therapy, cold weather or an attack of bronchitis which produce so great deterioration that independent performance is threatened. The main cause for unstable disability is frailty which they define as 'a condition or syndrome which results from a multi-system reduction in reserve capacity to the extent that a number of physiological systems are close to, or past, the threshold of symptomatic clinical failure. As a consequence the frail person is at increased risk of disability and death from minor external stresses' (p.315). As expected, they recommend the identification of frail individuals as an appropriate focus for prevention, rehabilitation, and public health programmes in old age.

Efforts over approximately a decade by experts concerned with the differentiation of the concepts of frailty, disability, and comorbid states, can be also seen in the work of Fried et al. (2004) presented in Figure 3.2.

Figure 3.2 Definition of frailty, disability, comorbidity, and their major health implications



In their work, Fried et al. (2004) present definitions for the concepts of frailty, disability and comorbidity, along with the results of a study asking geriatricians their view on frailty and disability, whether they thought they were the same concept, and the causality between them. They define *disability* as having difficulty with or being dependent when carrying out activities essential to independent living, including essential roles, tasks needed for self-care and living independently at home, and desired activities important to one's quality of life. Regarding *frailty*, they define it as a state of high vulnerability for adverse health outcomes, including disability, becoming dependent, falls, need for long-term care, and mortality. However, they also note how challenging it has been to find a standard definition of frailty that is widely recognised and valid in different settings, thus making current estimations of frailty "approximate and tentative".

In presenting the special difficulty in differentiating disability from frailty they affirm that given their similarity in associated outcomes (with the exception of frailty itself being a cause of disability), and the frequency of co-occurrence of frailty and disability, confusion between these concepts has been common. They continue by noting that: "According to current views, frailty can be defined as a physiologic state of increased vulnerability to stressors that results from decreased physiologic reserves, and even dysregulation, of multiple physiologic systems. This decreased reserve results in difficulty maintaining homeostasis in the face of perturbations. ... Although the early stages of this process may be clinically silent, when the losses of reserve reach an *aggregate* threshold that leads to serious vulnerability, the syndrome may become detectable by looking at clinical, functional, behavioural, and biological markers" (p. 256).

The results of the study with geriatricians show that their perceptions are that, although interrelated, these concepts represent three distinct clinical entities, and therefore, clinical management of each has its own unique content and challenges. Specifically, when asked about their views 50% of geriatricians surveyed stated that frailty is sometimes a cause of disability, for 40% it is always a cause for disability, while for the remaining 10% frailty is not a cause of disability. When asked if disability is a cause of frailty 12.5% said no, 75% said sometimes, and the remaining 12.5% said always. Finally to the question whether frailty and disability are the same 97.5% said no and 2.5% said sometimes. On *comorbidity* they present a formal definition as the concurrent presence of two or more medically diagnosed diseases in the same individual, and note that comorbidity heightens the risk of disability and mortality, over and above the risk from individual diseases.

The paper continues by presenting the interrelationships between disability, frailty, and comorbidity. They state that it is clear from experts' and geriatrician's views that while frailty is clearly distinct from disability and comorbidity, usually it overlaps with them both. In addition, they note how both frailty and comorbidity predict disability, and even when adjusting for each other; disability may aggravate frailty and comorbidity, while comorbid diseases may contribute, at least additively, to the development of frailty. Finally, they assert that these interrelations explain their frequent simultaneous manifestation and confirm why it is so relevant to clinically differentiate them so as to identify and plan interventions accordingly whether they are focused on prevention or treatment. Specifically, each condition confers specific needs and prognosis and therefore treatment for each of these conditions presents specific challenges and needs. Policy and strategic planning should be made accordingly as can be seen in Figure 3.2.

In a more recent publication that summarises the proceedings of the Second International Working Meeting on Frailty and Ageing held in Montreal in March of 2006, Bergman et al. (2007) present the key issues and controversies around the concept of frailty, its definition, and the way to implement or measure it. Following different researcher's concerns, they note that while the conceptual model adopted will affect the components selected to measure it and the methods used, the common inclusion or exclusion of certain criteria has been widely discussed, such as weight loss and other risk related behaviours. In addition, they note that it is very important to recognise that even when there may be common biological bases for frailty, there may be a wide array of pathways along which it develops. Thus, frailty that begins with cognitive decline may differ widely from a trajectory of frailty that begins with physical impairments.

One of the main points raised in the meeting was the need to determine if static criteria or components measured at a single point in time are appropriate to define a condition that by definition is dynamic, in that it changes over time as the person transitions through the pathway of good health to ill health (and back) or from stability to unstable disability. Thus, the need to create static or dynamic measures of frailty and their predictive power was discussed. There are at least two major advantages of using Frailty and its operation via an indicator or index. First, as a useful tool that allows to part from an organ or disease based measurement towards more comprehensive health-based and integrative ones. It is also noted for its usefulness in comparing the status of subset of older persons, identifying those in higher risk and hopefully targeting different interventions to them.

However, the risk of losing perspective by using such comprehensive indicators or as the authors put it “missing the trees for the forest” points to the need for the following. First, not losing attention to individuals with few or only one symptom or illness present who could be frail but not considered as such by a summary measure, while others with symptoms that mimic frailty may be erroneously considered as frail. Second, they consider that for some specific purposes, more simple measures of vulnerability may be adequate such as gait speed, grip strength, which are often present in surveys or clinical studies. Finally, the importance of not forgetting that using such measures do not shed much light on the specific impact of age, chronic diseases, symptoms, and other risk factors individually in the health and disability process.

The document ends with recommendations for the future of research on this subject. They note the need for studies that further our understanding of the dynamic relationship between frailty, its biological basis, impairments, and longitudinal changes in physical function as well as the contribution of socioeconomic, environmental, and behavioural factors. In addition, research diagnostic criteria should examine if and how the risk of adverse outcomes associated with the cluster of components is greater than that of any single component or the additive risk associated with the combination of components. In addition, the need to examine dynamic as well as static measurements ideally to identify transitions between states, its determinants, and causality with other factors should be noted.

From the empirical work reviewed we note how multiple studies confirm that measuring functional assessment and frailty status has turned out to be an appropriate tool to evaluate health status and overall wellbeing of the older adults because it provides objective data that may indicate future decline or improvement in health status.

Results from several studies, even when using different samples and methods, have noted the utility of summary measures or indicators such as frailty indexes as a component of stages of stability or instability in older age. For Campbell and Buchner (1997) for example, while a frailty index may be too indefinite to identify particular needs in an individual, properly defined, with the major contributing factors to frailty tested, it is a useful concept that reflects an essential component of old age which they call “unstable disability”. In addition, empirical studies have also noted that the concept of frailty has explicative significance by showing, among individuals, multiple changes related to ageing that contribute to the

different pace or speed in their deterioration process, etc. More work now seems to be needed in order to identify the different causation that each component may contribute.

Some of the main pros that have been identified with generating summary measures such as frailty indicators, are that they improve the understanding of the ageing process; their ability to characterise the heterogeneity of older persons; at population and clinical level, ability to define health and functional status beyond disability and morbidity; its value as an analytical tool that allows for identification of subgroups of vulnerable adults at high risk of *adverse outcomes* such as hospitalisation, falls, and death (Bergman et al. 2007).

For example, the goal of the team in Canada generating a Frailty Index for the older population in that country was to derive a characteristic variable from which it would be possible to suggest nontrivial predictions about the health status of this population group including different adverse outcomes. It has been widely recognised in the literature that frailty is associated with adverse outcomes (Fried et al 2001, Ferrucci et al 2004, Fried et al 2004, Mitnitski, Song et al 2004) and that it provides an accessible and useful tool for appraising individual and population health status from information which is readily available in many databases (Mitnitski et al. 2003).

Through the wide array of empirical work that has applied indicators of frailty, it is clear that such indicators are strong determinants of such outcomes and are also a valuable tool to identify subgroups of the population by different demographic and socioeconomic characteristics such as locality of residence, sex, age, partnership status, income level, educational attainment, among many others.

However, it is important not to forget that it is also noted how for clear reasons related with their construction these indicators should not be seen as tool to make policy decisions nor derive treatment for specific conditions (Bergman et al. 2007).

In addition, within a perspective of what has been called “successful” or “positive” ageing, it is clear that additional components of social mental well-being should also be included. Although still scarce and mostly based on small samples, there is already important information from some studies that show that frailty is closely related to quality of life, with individuals classified as frail generally scoring lower on health related quality of life scales than those that are not frail, and in most cases independently of socioeconomic and demographic variables (Puts 2006; Puts et al. 2007; Kanauchi et al. 2008).

In one of the few studies using larger samples, Masel et al. (2009) use the Hispanic Established Populations Epidemiologic Studies of the Elderly (EPESE) to investigate the relationships between frailty status and health related quality of life. They use a modification of the frailty index proposed by Fried and colleagues (Fried et al. 2001) and the Medical Outcomes Study (MOS) Short Form-36 (SF-36) to measure health related quality of life. Using multiple linear regressions to measure the effect of frailty category on the SF-36 subscale scores on one hand, and logistic regression to estimate odds ratios for the effect of frailty status on being in the lowest quartile of the SF-36 summary scales, they found that on all subscales of the SF-36 and both the physical and mental summary scales, being pre-frail or frail was associated with lower scores. In addition, frail participants had around 10 times the odds of scoring in the bottom quartile of either summary scale compared to the non-frail participants.

These results show the importance of including social and mental-health components in measuring overall wellbeing of older adults. It also reflects the need for adapting such studies elsewhere, as information becomes readily available.

It seems clear that Frailty is a multidimensional concept and there is still a great need for larger longitudinal studies that allow for clarification of its role as an indicator, as well as the role of its individual components and the weight each one may be contributing to, for example, neuro-degenerative conditions, cardiovascular and cerebral-vascular illnesses, etc.

In addition, there is a further need to explore the effects of the components of frailty, specifically whether they have an additive effect, or if some components combine synergistically. Finally, it is necessary to understand if frailty generally precedes disability or if it is a two-way process where they simultaneously cause each other.

Such studies should additionally include measurement that allows for a clarification of the role of childhood and adult socioeconomic conditions in overall frailty and an individual's pathway to disability and ultimately death. Finally, as it was mentioned before, social and mental-health components such as measurements of quality of life and positive affect should also be included in the analysis of older people's wellbeing in order to better understand their role in the ageing process and the way they interrelate or affect each other.

Without doubt these studies have been a breakthrough in terms of introducing different ways, applicable to a wide array of surveys, to measure conditions relevant to the ageing process such as frailty and disability.

Availability of information on frailty and disability in the ageing population in Mexico is still scarce, although the few studies to date allow identification of some relevant determinants, differences among groups, among other issues. Much work is needed however and especially of a kind that introduces more advanced methods that ideally allow for more robust results.

Learning from these national and international experiences it seems clearly important, when generating new information, to choose multi-dimensional measurements or indicators which best describe the local characteristics of the older population. Thus it was decided to include two different analyses of health of the ageing population in Mexico in this thesis. The first one is the generation of a Frailty Index following the work of Mitnitski, Rockwood and colleagues. In addition, the main determinants of frailty in the ageing population in Mexico according to this index and how the index is presented in different subgroups within this sample are estimated. These are presented in Chapter 4. The second one refers to the estimation of the determinants of disability in a sample of the ageing Mexican population using a widely used and validated scale. This is presented in Chapter 5.

Chapter 4 Determinants of frailty in a sample of the ageing population in Mexico

4.1 Introduction

As noted in Chapter 3, the past decades have seen an increasing interest by medical and academic researchers in trying to explore and define the multi-factorial process older adults experience in later life. The concept of frailty is one of the topics that have been increasingly explored to do so. Although there have been many attempts to define frailty and to synthesise it in a single measure, coming to a unique measure and even an agreed conceptualisation of frailty has proved very difficult.

One thing that is clear is that frailty has a similar meaning for most people interested in studying this phenomenon. Frailty is identified by the co-existence of multiple symptoms or ailments in several physical systems in an individual. Frailty is also characterised by a state of increased impairment and vulnerability that puts the individual at further risk of an adverse outcome including death. In contrast to other indicators such as morbidity and disability, frailty usually includes not only physical but social domains such as family support, access to social networks, etc.

There are several main concepts behind frailty and the efforts to define and measure it. First, it seemed important to obtain a way to identify or separate the effects of factors such as age in overall wellbeing of older adults. It is clear that as individuals age they will likely accumulate symptoms and conditions however, not all people at a specific age are in the same condition. Thus, it is necessary to separate chronological age from more complex conditions and definitions of wellbeing.

In the same way, the need to move from morbidity statistics and number of chronic diseases an individual has, to the impact these are having on wellbeing of the older adults seemed an equally relevant issue to analyse and include in measuring the wellbeing of older adults. It is known that chronic diseases do not affect all individuals in the same way, and that behaviour and risk factors, childhood conditions, among other individual-level factors have a large impact on incidence and how this diseases progress. Thus, it was thought that these differences should also be taken into account.

In sum, it seems that whatever the differences or uncertainty regarding a unique conceptualisation of frailty and its measurement, there is wide agreement that this is a concept that allows research of older adults' wellbeing by going beyond health indicators such as morbidity and number of chronic diseases. It also goes beyond measures of physical disability or inability to carry out a number of daily activities. And, as mentioned earlier, it may include social domain factors such as family support and social networks available.

This is sufficient evidence that research on frailty, its measurement, and its application are relevant by itself, but also in related research as determinants for example, of different outcomes such as mortality and survival. Finally, it can be considered as a relevant input to the generation or modification of health policies and programmes that can benefit from this information.

This chapter aims to replicate the work by Mitniski, Rockwood and colleagues that was introduced in Chapter 3 by generating a Frailty Index for the population 50 years and older in Mexico.

The chapter is organised as follows. Firstly, following the introduction, the methods to generate the Frailty Index and the steps followed in the generation of a Mexican version of the index are explained. Health, demographic, and socio-economic surveys commonly encounter problems due to missing values in their responses.

The Mexican Health and Aging Study, MHAS used in all estimations undertaken in this thesis is not an exception to this. Therefore, it was decided to deal with non-response and missing values by utilising multiple imputation techniques in the analyses. The problem of non-response and missing values, its presence in the MHAS data sets, as well as the imputation strategies are also included in section 2 of this chapter. In this section, the data and the coding of the variables needed to construct the index are also presented.

Section three presents the statistical analyses generated using the frailty index scores. The chapter continues by presenting the results of the frailty index scores for the sample and the results of the statistical analyses. Finally, the last section presents a discussion around the value of generating the index and of the main results of the study.

4.2 Methods

4.2.1 Generation of the Frailty Index

In their original work Mitnitski, Rockwood, and colleagues refer to the Frailty Index as "...a simple means of summarising health status and its variability with age..."

Their approach in measuring frailty is by generating a simple count of different symptoms, illness, and other conditions that an individual presents and from this conclude a certain frailty status. As described by the authors: "This approach differs from others in that it does not specify which deficits, or which combinations of deficits must be present for someone to be considered frail" (Mitnitski et al., 2005, p. 2184).

The underlying concept in their work when constructing a frailty index¹¹ is that the more deficits or problems an individual has accumulated the more vulnerable and frail he or she will be, compared to individuals who have less deficits or none at all.

In order to construct the frailty index, the number of deficits is x divided by a previously defined number of conditions n (variables). That is, the

index is generated from a simple fraction of $\frac{x}{n}$.

"The average index value at any given age is simply the arithmetic mean of the individual values" (ibid, p. 2185)

4.2.2 Non Response and missing values

As is common with health, demographic, and socio-economic surveys, missing values in the MHAS data set could represent a problem when analysing the data given its reliance on self-reported questions and measures. The problem arises when missing data – possible reasons will be explained later on – are present in the responses and the statistical packages work or undertake the estimations only with those cases for which information is present for all of the variables, called complete cases. In consequence, one could lose a significant percentage of the observations in the estimations producing less robust or even biased results.

¹¹ Still, the authors do specify a few rules or restrictions determining which deficits can be included and how they should be summed. First, given that they assume that as individuals accumulate deficits, the more likely they are to be frail; deficits chosen should be restricted to those that have the possibility of accumulating with age (e.g., fragile bones, compared to congenital abnormalities). Second, although age-related, variables included should not saturate too early. For example, most individuals will need correction for near vision by age 70, compared to glaucoma which is age-related but does not approach universal values at any age). Third, they recommend that individual variables have few missing data and imputation strategies are suggested in order to obtain full data (Mitnitski et al. 2005, p. 2185)

Given that MHAS is a nationally representative sample of individuals 50 years and older, and it is the interest of this study to make inferences about this population group, a decision was made to work with a full sample instead of complete cases.

The crucial role of the mechanism in the analysis of data with missing values was largely ignored until the concept was formalised in the theory of Rubin (1976), through the simple device of treating the missing-data indicators as random variables and assigning them a distribution (p11).

Following the literature on missing data analyses, the first step is to identify the patterns and mechanisms leading to missing-data in the study sample. The missing patterns let us know which values are observed in our data and which values are missing. On the other hand, missing data mechanisms allow for the identification of the relationship between the values missing and those observed.

Some examples of missing data arise in the following situations: a) in cases where there is univariate missing data, that is, missingness is confined to a single variable; b) in cases with unit missing data (a Y_k single incomplete variable is replaced by a set of variables all observed or missing on the same set of cases, e.g. subset of individuals lost, individuals refuse to answer, failed/non-contact resulting in not completed questionnaire; and c) when we have item non response, that is, missing values on particular items in the questionnaire.

Other issues that are common include attrition in longitudinal studies; file matching problem with two sets of variables never jointly observed; latent-variable patterns with variables that are never observed; non-response in a binary outcome measured at three time points; causal effects of treatments with survival and quality of life outcomes; non-response in opinion polls (Little and Rubin, 1987).

Mechanisms of missing data are MCAR-missing completely at random, when there are no systematic differences between complete and incomplete records; MAR-missing at random, when the probability of missingness does not depend on unobserved information but the pattern of data missingness is traceable from other observed variables in the dataset; and NMAR-not missing at random, when the probability of missingness depend on unobserved information and is not predictable from other variables in the dataset.

Depending on the patterns and mechanisms of missing data in the sample, different techniques can be used to handle missingness, mainly: a) "complete-case" analysis based on completely recorded units; b) weighting procedures, imputation-based procedures where the missing values are filled in and the resultant completed data

are analysed by standard methods; and c) model-based procedures using parameter estimation by procedures such as maximum likelihood (ibid p 11-20).

4.2.3 Data

This study uses data from the Mexican Health and Ageing Study, MHAS¹². MHAS is a prospective panel study of a nationally representative sample of Mexicans aged 50 years and over and their spouse/partners regardless of their age (representative of 13 million Mexicans born prior to 1951 and their spouses). The sample of MHAS respondents were identified from the 2000 National Employment Survey/Encuesta Nacional de Empleo, ENE.

Given that one of the main objectives of the study is to compare the health dynamics of older Mexicans compared to Mexicans who migrated to the U.S, six Mexican states, which are origin of 40% of all migrants to the U.S., were over-sampled at a rate of slightly less than 2:1.

It is important to note that MHAS includes only the non-institutionalised segment of the older Mexican population. This implies by definition that the survey and therefore the analyses are only representative of the community-dwelling older population in Mexico. As has been mentioned in studies of the older population in other countries, not covering the institutionalised population could be a problem or produce biased results. As mentioned in the background chapter, in Mexico, extended families with older adults living with their children, grandchildren, or other relatives are still the norm (Zuñiga and García 2008). In addition, there is some evidence that only a very small percentage of the oldest population in the country are institutionalised as noted by Gutiérrez Robledo et al. (1996) who conducted a study for Mexico City and estimated that at the time of the 1990 Census less than 0.5% of individuals 60 years and older lived in institutions including convents, penal institutions, and those providing residential care for the chronically disabled.

However, as noted in chapter 2, there are currently no accurate data on institutionalisation of the older population in Mexico. The main problem is that there are no formal and comprehensive registries, nor regulation, either at national or local levels, of all the for-profit and not-for-profit institutions that provide any type

¹² The existing two waves of the MHAS (2001 and 2003) were supported by a grant from the National Institutes of Health/ National Institute on Aging. The study is a collaborative effort among researchers from the Universities of Pennsylvania, Maryland, and Wisconsin in the U.S., and the National Statistics, Geography and Informatics Institute, INEGI (Instituto Nacional de Estadística, Geografía e Informática) in Mexico. All field work was done by INEGI who performed in-person interviews. Public access to information on the project, the data sets, supporting documents, and publication is available from the University of Pennsylvania at <http://www.mhas.pop.upenn.edu/english/home.htm>

of services for the older population. In consequence there is great uncertainty on the quality and efficiency of their services, and the impact they have in the overall wellbeing of this population group.

It will be very interesting to see if the Census 2010 is able to provide at least some information on their numbers, but the information currently available concerns community-dwelling individuals. However, given that they represent a large majority of the older citizens these data are enormously valuable. As mentioned earlier this may imply underestimation of some relevant variables such as comorbidity and difficulty in performing everyday activities.

The baseline survey was conducted in the summer of 2001, and a first follow-up was conducted in the summer of 2003. The main subjects covered by the study are socio-demographic characteristics, health, difficulty with daily activities, cognition, use of health services, family networks, migration history, work trajectories and current employment, income, retirement, pensions, and anthropometric measures for a sub-sample of the population.

In the 2001 baseline survey there were 11,000 households with at least one person of eligible age selected for the study. If more than one age-eligible person resided in the household, then one was randomly selected for the study prior to the fieldwork. If the selected MHAS person was married or in a consensual union, with the spouse residing in the same household, then the spouse or partner was also interviewed as part of the MHAS regardless of his/her age.

For the 2003 re-visit, all age-eligible persons interviewed in 2001 were targeted for follow-up as well as their spouse/partner. If the couple had split, separate interviews were attempted with each individual and new spouse/partner if applicable.

Additionally, if the respondent had died, an interview was sought with a next-of-kin (widow or child) or informed respondent. MHAS 2003 had the target of re-visiting 9,718 households. Of these, 37 had split into two and it was possible to have information on both. Thus, the total households to visit in 2003 were 9,755.

Direct interviews were required in all cases, with the exception of individuals in poor health, hospitalised, or temporarily absent in which proxy interviews were performed. The baseline study (2001) interviewed 15,186 individuals (57.17% women). Of this total 1,032 (6.8%) interviews were performed using a proxy respondent.

According to data reported by MHAS in 2001, of the 1032 interviews conducted by a proxy respondent, 31.10% (321 interviews) needed a proxy informant due to illness or health problems of the selected respondent. Even when the proxy-questionnaires include an important part of the information, all self-reported data is excluded. For example, even when the proxy respondent is asked if the older person has been diagnosed with a number of chronic diseases, or if they have noticed changes in their ability to perform activities such as manage their money, self-reported items are not collected.

Therefore, highly relevant information such as health status, items on depression or other self-reported symptoms such as swollen feet, involuntary urine loss, severe fatigue, etc. are not included. In similar way, tests such as the one evaluating cognitive status are not performed for these respondents. Given that all this information is considered fundamental for the generation of the frailty index and the rest of the estimations generated for the thesis, proxy interviews were dropped from the sample. This leaves us with an initial working sample of 14,154 individuals: 5,936 men (41.94%) and 8,218 women (58.06%).

Having decided to drop proxy interviews, it is necessary to reflect on possible issues around this decision. The main question arising that needs consideration is the reason why these respondents needed a proxy respondent. If it is the case that these individuals show an advanced state of impairment, illness, advanced age, dementia, or other conditions, dropping them from the sample would delete relevant information on how the more frail individuals are going through the ageing process. This in turn, could bias or underestimate results in different estimations and should be taken into account when analysing the results.

However, having reviewed the problems with missing values and the fact that observations with missing data are usually dropped from the estimations by statistical packages, it is likely that they would have had been excluded from the estimations anyway. In addition, we may consider that 321 proxy interviews due to health reasons out of an initial sample of 15,186, approximately 2%, may not bear as heavy a weight as initially it could have been expected. In sum, although for the present analyses, dropping proxy interviews from the sample was considered the most accurate option, it is not done without knowledge of its potential problems, especially in terms of causing underestimation or possible bias of the estimation results. Separate analysis for those respondents needing proxy interviews or at least those needed due to health problems or hospitalisation remains an issue that should be addressed in future research.

The MHAS sample includes population 50 years and older and their spouses, independently of the age of the latter. Given that the age group of interest for the study is 50 years and older observations of spouses younger than 50 years of age were also dropped from the working sample. Thus, an additional 1669 observations were deleted. This resulted in a total sample of 12,485 individuals (54.18% women) with a mean age of 62 years and standard deviation of 9.4 years.

Of this initial sample 3,109 respondents have no formal education (24.9%), 53.28% completed only primary school, and the remaining 21.82% completed secondary education or higher. Regarding civil status, 69.4% are married or in a consensual union, 3.92% single, 8.45% divorced or separated from their partner, and 18.23% reported to be widowed. As a reflection of the social changes in the last decades in Mexico, in the study 66.59% of this population group is living in more urban areas, defined as localities with more than 100,000 individuals.

4.2.3.1 Non-response and missing values in MHAS

In exploring the possible problem of missing data in the MHAS data, there are two main issues to consider. First, it is relevant to identify the specific patterns and observed mechanisms on why observations are missing in the different variables of the MHAS to be used for the construction of the frailty index. Equally relevant, it is necessary to investigate how these mechanisms and patterns are likely to affect estimations if they are ignored and the possible need to replace the non-response and missing data with likely information using imputation techniques.

An analysis of missing patterns in the data shows the following. There are 1,032 individuals that did not respond directly to the questionnaire and proxy interviews were done, thus presenting missing values in all variables of interest. Given the relevance of these variables for the study, these individuals were dropped from the sample for analysis.

Given that a main part of the index refers to health and morbidity data, it was relevant to investigate why 2.6% (394) of all cases (individuals) showed missing values for all questions which refer to being diagnosed with, and treated for different chronic illnesses. Looking at the data, in a previous question these individuals reported they have never seen a medical doctor.

Although their information is missing this does not mean, or one cannot assume that they do not, for example, have chronic illnesses, do not suffer from depression, among other things. It was decided that given the importance of these

variables, these individuals –and their attached information- should be “included” in the analysis.

The second block of variables refers to cases with non-response data given individuals’ selection of options *don’t know* or *refused to answer* in different questions of the survey. Although most variables to be used have a very small proportion (0.01—1%) of cases with a Don’t Know/Refused answers, a problem arises because most of them on occasion make one of these answers or both. Therefore, if it were decided to work with “complete-cases” instead of handling missing data, estimations would significantly reduce the sample, with the consequent loss of robustness in the analysis or possible bias due to loss of individuals in the estimations.

Within these variables, two special cases were identified, that of self-reported weight and height. Given that these two variables are used in the calculation of the Body Mass Index, BMI which is included in the generation of the frailty index of the older population in Mexico, it was also decided to use the full sample by trying to estimate the missing values.

Table 4.1 Missing data in self-reported weight and height

	Weight		Height	
	<i>Frequency</i>	<i>%</i>	<i>Frequency</i>	<i>%</i>
Refused (888)	21	0.14	27	0.18
Don’t Know (999)	1595	10.51	3413	22.48

For difficulty with performing Activities of Daily Living, ADLs and Instrumental Activities of Daily Living, IADLs, in addition to a small proportion (0.01-2.61%) of individuals who chose the options Don’t Know or Refused to answer some question, there are two additional response options, Cannot do and Does not do, that have to be treated in order to have a satisfactory coding of the variables that populate the Frailty Index.

When the person responds she/he has difficulty with performing an activity The interviewer has to verify whether they cannot do it due to health or disability issues (e.g., not being able to jog a kilometre because they are confined to bed or in a wheelchair), or whether they do not do the activity because they have someone who does it for them (e.g., shopping for groceries or cooking a hot meal).

The variables reflecting difficulties included in the frailty index have to classify individuals into one of two categories of a binary variable where 1=having difficulty with a specific activity. Thus, individuals who answer they cannot do a specific activity will be classified/coded as having a difficulty (assuming them as an extreme case of having such difficulty).

On the other hand, individuals who responded that they do not do a specific activity were coded as missing in order to be able to handle these cases by using imputation techniques for missing data. Whether or not they have difficulties will be imputed in order to not lose them in the estimations.

The MHAS survey has a complete section for evaluation of cognitive impairment. Given that cognition is considered a fundamental factor in terms of frail status, recoding was also performed in order to treat missing values. After careful revision and consultation, it was decided that for the recoding of the figure-copying and visual-scanning exercises the following steps were taken for recoding of the variables. First, those cases that refused to respond were coded as missing in order to impute.

Second, recode those who could not do the copying figures exercise due to vision problems to missing in order to impute. This coding was decided given they having vision problems indicates a disability but we do not know anything about their cognition ability, and thus it was considered best to have an imputed value than a missing value. Similarly, refusing to do the test may be due to several reasons for which we do not have information, so instead of categorising them as unable to do the test due to cognitive impairment, or just dropping them from the sample, it was considered better to impute their values.

Initial missing cases in the cognition evaluation includes those who did not do the tests because the interview was not in Spanish, those who refused answering if they have problems holding a pencil and those who cannot hold a pencil due to health problems. The same recoding strategy was followed for these cases as to retain the observations in the sample.

4.2.4 Imputation strategy

Following a review of the literature and consultation with academics, the Imputation by Chained Equations, ICE method was selected for imputation of missing data in the sample used in this study. This programme was developed to use with the Stata10© software (StataCorp 2007).

Multiple Imputation by Chained Equations methods includes the following steps. First, a random subset of the data is selected. Then a value for each missing case in a variable is estimated using a chosen regression model e.g. logit, probit, etc. depending on the nature of the variable, that is, categorical, ordinal, etc.

From these estimations, the closest observed values to that estimate are chosen in order to replace the missing values. The programme then switches to the values of the next variable with missing values and the process is repeated again for each variable for a predetermined number of cycles. In the end a defined number of "new" data sets m is created, which are finally combined in the estimation analysis.

This method of multiple imputations by chained equations has been widely used and proved to give satisfactory results in many studies. It is also the preferred method in use in several national statistics offices such as in the US and the UK¹³ for treatment of missing Census data.

Multiple Imputation has been noted to have several advantages, and as a sound method given that it may include other variables not in the substantive model in the imputation of a particular variable, using as much information and additional characteristics of the individual in the process, which can lead to additional efficiency (Carpenter et al., 2006, Carpenter et al., 2007, Carpenter, 2007).

4.2.5 Generation of the Frailty Index

The Frailty Index for the ageing population in Mexico was constructed using data from the Mexican Health and Ageing Study, MHAS. The first step was to identify and recode the variables that populate the Index. These variables were selected from a number of illnesses, symptoms, and impairments that generally rise with age and can be present in the study sample. Following the work of Mitnitsky, Rockwood, and colleagues, these terms are defined as *deficits*.

The Frailty Index for the ageing population in Mexico is constructed using a number of deficits chosen from self-reported and direct evaluation tests included in the MHAS. The variables or deficits included are intended to reflect the presence and severity or absence of illnesses, symptoms, difficulty to perform daily activities, depression, and cognitive function. As it was mentioned earlier, the index is X constructed as the number of deficits an individual has accumulated, divided n by the number of total conditions (variables) selected for the index.

¹³ For a review of some of the sources using multiple imputation within official statistics and research institutions in the United Kingdom: <http://www2.napier.ac.uk/depts/fhls/peas/imputation.asp>

Following the methods of the original Frailty Index, each deficit was given a binary coding to represent frequency, presence, or severity of a condition. For variables with ordinal scales intermediate values were assigned in order to place them on a [0, 1] interval. For example, variables with a scale of excellent, very good, good, fair, and poor were assigned the values of 0, 0.25, 0.50, 0.75, and 1 respectively.

In addition, socio-demographic variables in the analyses include sex, age, marital status, household composition, education attainment, if the individual had serious health problems before age 10, speaking an indigenous language (indicator in Mexican surveys of belonging to an indigenous group), belonging to one of six high migration states, and living in more urban/rural communities.

There are seven dimensions in which the covariates are grouped. These are presented in Table 4.2. The first one has to do with the diagnosis of chronic illnesses. Although it has been noted that number of chronic illnesses is not necessarily related to old age and may not cause any disability or frail status for long time, it is considered as a good marker of overall current and future health. There are 7 chronic illnesses in the MHAS that are included as deficits in the Index: hypertension, diabetes, cancer, respiratory illness including emphysema, heart attack, stroke, and arthritis/rheumatism. For their inclusion in the Index, a binary variable was generated which reflects the presence or absence of each disease (1=yes).

Table 4.2 Dimensions included in the Frailty Index

1. Measures of Health Status
➤ Chronic illnesses: hypertension, diabetes, cancer, respiratory illness, heart attack, stroke, arthritis/rheumatism
➤ Other conditions: hearing and visual impairment, pain, fatigue, fractures, etc.
➤ Self-reported health
2. Measures of Functional Ability physical activity/mobility
➤ Measure of having difficulties in performing Activities of Daily Living, ADLs
➤ Measure of Instrumental Activities of Daily Living, IADLs
3. Measure of Cognitive status
4. Measure of Depression
5. Socio-Demographic characteristics
➤ age
➤ sex
➤ marital status
➤ education
➤ Income/assets
➤ access to social security or other insurance
6. Measure of Social Support/Social Network
➤ Household/Family composition
➤ Indicator of help received to help needed (with ADLs and IADLS)
7. Indicator of Risk Factors (in MHAS)
➤ tobacco
➤ alcohol
➤ exercise

Additional factors included in the first dimension include other health conditions or symptoms such as having had fractures in the last year, impairment of hearing and vision, suffering constant pain, fatigue, constant leg pain, among others. In a large number of studies, self-reported health has been shown to be a valid indicator of true health status and it is included in this dimension as current self-reported health status and as status compared to that 2 years earlier.

For most of these variables, the coding selected was again to show the presence or absence using binary variables. Some exceptions are "suffering pain" which is an ordinal variable including the following categories: no pain, mild pain, moderate pain and severe pain. The second case is self-reported health status that has five categories: excellent, very good, good, fair, and poor.

Measures of difficulty with performing everyday activities are included as the second dimension. These are considered relevant given that needing and receiving help with ADLs and IADLs is a strong indicator of overall health and frailty status. There are nine activities of daily living and 4 instrumental activities of daily living included in the Index. These variables are coded as binary (1=yes) indicating the presence or absence of difficulties with performing each activity.

Depression and Cognitive Function are included as third and fourth dimensions given that they are frequently noted as strong indicators of overall wellbeing and functioning, especially in the case of older individuals. Depression is classified using the Center for Epidemiologic Studies Depression Scale, CES-D¹⁴ (Radloff LS and the National Institute of Mental Health 1972).

The scale is a 20-item, self-reported depression scale developed to identify depression in the general population. The MHAS includes 9 of the 20 items of the scales. The validity and reliability of a CES-D with nine questions as used in the MHAS was assessed by Aguilar-Navarro et al. (2007) who found the depression

¹⁴ CES-D Scale (Department of Health and Human Services, National Institute of Mental Health) www.holzerent.com/pages/forms/w/ces-depr%20scale.doc, Center for Epidemiologic Studies Depression Scale (CES-D) Scoring. The CES-D consists of 20 questions. Patients are instructed to circle the number for each statement that best describes how often they felt or behaved this way during the past week. The score is the sum of the weights of the 20 items. The weight for each item corresponds to the number chosen for each (0-3), except for items 4, 8, 12, and 16, which are reversed (3-0). The possible range of scores for the scale is 0-60. The following cut-off scores best approximate the severity stages of depression: 0-9= none or minimal, 10-16= mild, 17-24= moderate, and 24= moderate to severe. Scores greater than 16 are considered to reflect the need for further assessment, and further evaluation of the patient for depression. Additional information consulted at CESD by L.S. Radloff and the National Institute of Mental Health, USA, 1972; In: Measuring Health A Guide to rating Scales and Questionnaires, Ian McDowell, Third Edition, Oxford University Press, 2006, pp. 350-358.

questionnaire included in MHAS valid and trustworthy, allowing reliable screening for the presence of depression in the older population.

For assessment of cognitive impairment MHAS includes five sections taken from the Cross-Cultural Cognition Examination, CCCE generated by Glosser et al. (1993). Instead of questions, the respondent is asked to do some activities that reflect the cognition ability of the person, while other activities require more mental ability from the respondent. The battery of the Cross Cultural Cognitive Examination includes eight domains for screening¹⁵. In their definition of the criteria for impaired performance or failure of the CCCE, Glosser et al determined that impaired performance of two or more of the five tasks would constitute failure of the screening portion of the test. The MHAS performed the brief five-minute series of exercises of the CCCE: construction and construction recall of geometric designs; verbal learning and verbal recall tasks, and visual scanning.

Coding of cognitive functioning variables

a) Copying of figures and Figure recall

Each eligible individual has to copy two figures shown by the interviewer. Each figure is graded as one (1) if the figure was performed correctly or zero (0) if it was not. Scores for both figures are added up. A total score of two means the figure test is passed. The variable has three categories 0=Zero figures copied correctly, 01=One figure copied correctly, 02=Two figures copied correctly. In addition, item responses include 80=Refused to do the exercise (573 cases-4.29%), 88=could not do it because of vision problems (187 cases-1.87%), and 772 cases with missing values (not Spanish language, refused to declare if they have problems in holding a pencil, or cannot hold pencil, or refused to hold pencil).

After some questions, the individual is asked to recall the figures she/he drew and to draw them again. The grading criterion is the same as with the first copying of figures.

¹⁵ The eight domains are Attention, Language, Visual-spatial, Verbal Memory, Visual Memory, Recent Memory, Abstraction, and Psychomotor Speed. It includes a brief (5-minute) screening procedure that is intended for administration to all subjects and a more extended (20-minute) mental status examination that is intended for administration only to those subjects who fail the screening (Glosser et al. 1993). Before starting, the interviewer has to verify the individual complies with the inclusion criteria that the individual does not have any major health or mental disability that prevents her/him to complete the exercises (there is a specific proxy cognition evaluation section), and that the main language of the interview is Spanish. Of the total individuals eligible for direct interview 14,129, 167 (1.18%) were not using Spanish as language of interview and therefore they did not receive this section of the interview.

b) Verbal immediate recall and Verbal delayed recall

In this exercise, the interviewer reads aloud eight familiar words to the respondent who has to repeat as many as she/he can remember. There are two lists of words in the survey. Of all eligible individuals to perform the test (14,129) 7074 were selected for List A (50.67%), 6329 (45.33%) for List B, and 558 (4%) individuals refused to do the test. Each word remembered correctly gets one point and the total of words is summed, a total of 6 or more words recalled means passing the verbal learning test.

After a number of questions and without previous warning, the verbal recall test is done by the interviewer asking the respondent to recall and repeat as many of the eight words read previously as possible. The scoring is the same as for the immediate verbal recall test, and the respondent passes the verbal delayed memory recall test with a grade of 4-8 words. There are two binary variables one for the immediate recall and one for the delayed recall to show if the individual passed or not each of the tests (1=yes).

c) Visual Scanning

In this test, "The subject's task is to identify all exemplars of a designated target stimulus by circling items that are embedded in an unstructured visual array. The total number of targets correctly detected in 60 seconds is scored" (Glosser et al., 1993, p. 933). In the MHAS, the respondent passes the visual scanning with a grade greater than 24. For the Index, a binary variable showing if the individual passed the test or not was generated (1=yes).

The sixth dimension included in the study refers to socio-demographic and household characteristics such as living alone (1=yes), age (4 age groups), and gender (1=male) are included as the seventh dimension for the analysis. The descriptive statistics of the deficits and variables included in the Frailty Index are presented in Table 4.3.

Risk factors are included as the last dimension given their prevalence and predictors of many chronic illnesses. The risk factors included are if the person exercises or does hard physical work regularly which could act as protector for many illnesses, and are recoded as a binary variable (1=yes). Secondly, variables that reflect if the individual currently smokes and drinks are included. The coding of these variables follows the work of (Gonzalez and Ham-Chande, 2007).

In the case of smoking, a categorical variable distinguishes those who do not smoke; low consumption for those who smoke between 1 and 6 cigarettes a day, moderate if they consume between 7 and 10, and high if the consumption exceeds 10 cigarettes in a day. For drinking, a categorical variable distinguishes: a. those who do not drink; b. occasional drinkers if they consume one alcoholic drink a day; c. moderate if they consume more than one but no more than three in a day; and high level drinkers when they consume more than three drinks a day. Body Mass Index is included as the third risk factor in the index. Although there have been some arguments in favour of generating country or region specific Body Mass Indexes, for this study, the World Health Organisation's International Classification was used¹⁶.

Table 4.3 Deficits included in the Frailty Index

Deficits	Scale	Levels	Mean (SD)/%	% Missing
<i>Chronic illness</i>				
Hypertension (1=yes)	(0/1)	2	35.52	8.80
Diabetes	(0/1)	2	14.92	8.77
Cancer	(0/1)	2	1.79	8.64
Respiratory illness	(0/1)	2	5.88	8.62
Heart Attack	(0/1)	2	3.12	8.66
Stroke	(0/1)	2	2.32	8.57
Arthritis/Rheumatism	(0/1)	2	19.24	8.69
<i>Other health conditions</i>				
Fractures (any bone including hip)	(0/1)	2	12.00	8.10
Vision	(0/1)	6		6.86
Excellent			2.72	
Very Good			8.18	
Good			39.60	
Fair			33.00	
Poor			9.34	
Legally blind			0.27	
Hearing	(0/1)	6		7.63
Excellent			5.04	
Very Good			12.14	
Good			51.14	
Fair			19.40	
Poor			4.58	
Legally mute			0.06	
Pain	(0/1)	4		3.72
No pain			54.60	
Mild			12.70	
Moderate			16.09	
Severe			10.29	
Severe fatigue or exhaustion	(0/1)	2	25.68	6.41

¹⁶ Body Mass Index (BMI) is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults. It is defined as the weight in kilograms divided by the square of the height in metres (kg/m²). The levels of the classification are defined at: <18.50 as Underweight; 18.50-24.99 as Normal range; >=25 as Overweight; and >=30 as Obese. Source: Adapted from WHO, 1995, WHO, 2000 and WHO 2004. Last accessed 23 July 2009 http://apps.who.int/bmi/index.jsp?introPage=intro_3.html

Wheezing, coughing, passing phlegm	(0/1)	2	17.30	6.4
Pain in legs while or after walking	(0/1)	2	40.66	6.39
Stomach pain, diarrhea, indigestion	(0/1)	2	18.7	6.38
Involuntary urine loss	(0/1)	2	7.55	6.40
<i>Self-reported health</i>	(1-5)	5		6.23
Excellent			1.75	
Very Good			3.77	
Good			28.27	
Fair			44.29	
Poor			15.67	
Health problems before age 10	(0/1)	2	10.32	7.44
Depression	(0/1)	2	37.00	8.70
<i>Risk Factors</i>				
BMI			27.26 (5.09)	30.06
Smoking			15.94	6.24
Drinking			28.86	6.25
Regular Exercise-Physical Work	(0/1)	2	30.95	6.96
<i>Difficulty in performing daily living activities</i>				
Walking several blocks	(0/1)	2	24.05	7.09
Sitting for about two hours	(0/1)	2	17.24	6.87
Getting up from chair after sitting long	(0/1)	2	26.49	6.7
Stooping, crouching, kneeling	(0/1)	2	34.85	7.03
Extending arms above shoulder level	(0/1)	2	10.84	6.67
Pulling or pushing large objects	(0/1)	2	19.87	8.08
Lifting/carrying objects (5kg)	(0/1)	2	18.6	7.61
Picking up a (small) coin (1MXN)	(0/1)	2	3.14	6.64
Dressing incl. putting on shoes/socks	(0/1)	2	6.56	6.88
Preparing a hot meal	(0/1)	2	3.28	12.19
Shopping for groceries	(0/1)	2	5.38	10.0
Taking Medications	(0/1)	2	2.37	7.06
Managing money	(0/1)	2	2.05	7.26
Cognitive impairment	(0/1)	2	9.23	13.37

4.3 Statistical Analysis

The first step in generating the frailty index using full data was to make sure all variables were recoded as needed and a description of missing data patterns well identified in order to construct the multiple imputation data programme.

After the missing patterns were identified and variables properly coded, the Stata© command for imputation by chained equations, ICE was constructed. This command requires a precise definition of a prediction equation that will be used for each (independent) variable to be imputed and its predictor variables. It also requires an extensive programming for example, in order to account for multilevel categorical variables. The complete ICE programming command used is presented in Appendix 1.

After the Frailty Index was constructed, the first step in the analysis was to explore the distribution of the frailty index score. Descriptive statistics of the frailty index and the relevant socio-demographic variables were calculated. As an additional exploration tool, histograms of the frailty index were generated for the pooled sample and for men and women separately.

As a second step, the average frailty index was plotted against chronological age. Scatter plots for the pooled population, men, and women were generated separately. Linear regressions were estimated and the fitted curves were included in the plots. A 95% confidence interval for the means (score) was defined and was additionally added to the plot.

As presented in the background chapter, Mexico has large inequalities in many aspects that may have a direct effect on health and frailty status. Therefore, the third step in the analysis consisted of basic descriptive analysis of the index score by different socio-economic and demographic characteristics of the sampled population.

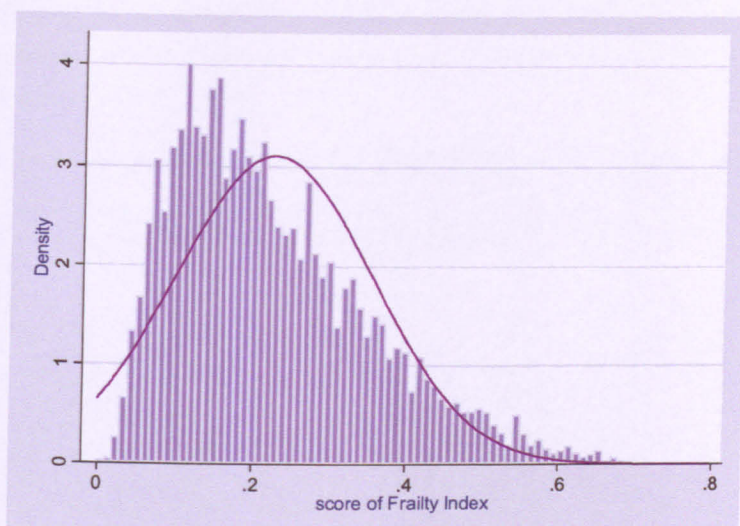
In the final step, tests of differences between groups were performed in order to explore possible differences in frailty among different groups of the sample population. Given that most of the dependent variables included in the frailty index have two or three levels and our independent variable frailty index score is ordinal, the Kruskal-Wallis equality of population rank test was chosen (Hazard Munro, 2005).

The Kruskal-Wallis H test is used to compare two or more groups and thus analogous to the parametric analysis of variance. In these techniques, scores for subjects are converted into ranks, and the analyses compare the mean ranks in each group (Hazard Munro, 2005). An additional advantage of this non-parametric test over others is that it does not assume a normal distribution of the independent variable. This is highly convenient because the distribution of the frailty index is not expected to be normally distributed.

4.4 Results

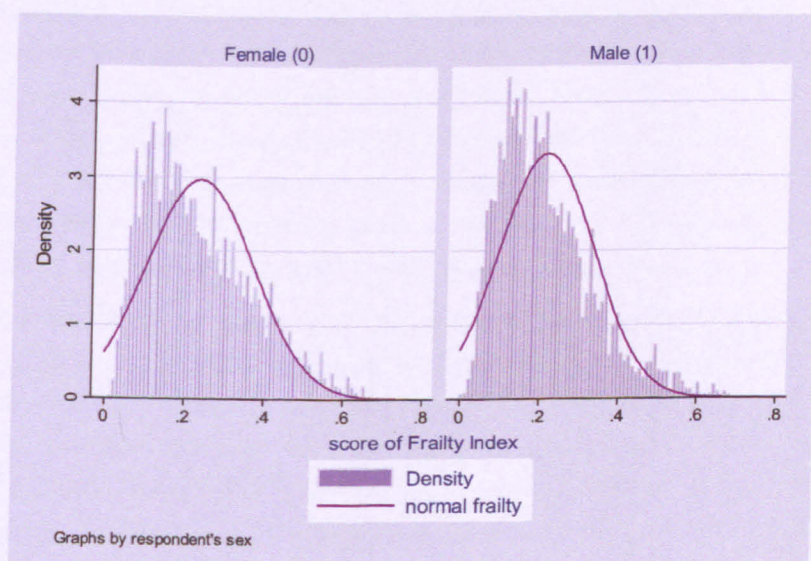
The results of the descriptive analysis of the data show that the mean of the frailty index score for the pooled/overall sample is 0.21. The mean score for females is 0.223 and 0.195 for men. This is clearly observed in the histograms of the score (Figures 4.1-4.2). The histograms clearly show how the score is not normally distributed, not symmetric, with a positive (right) skewness.

Figure 4.1 Histogram of Frailty Index, pooled sample



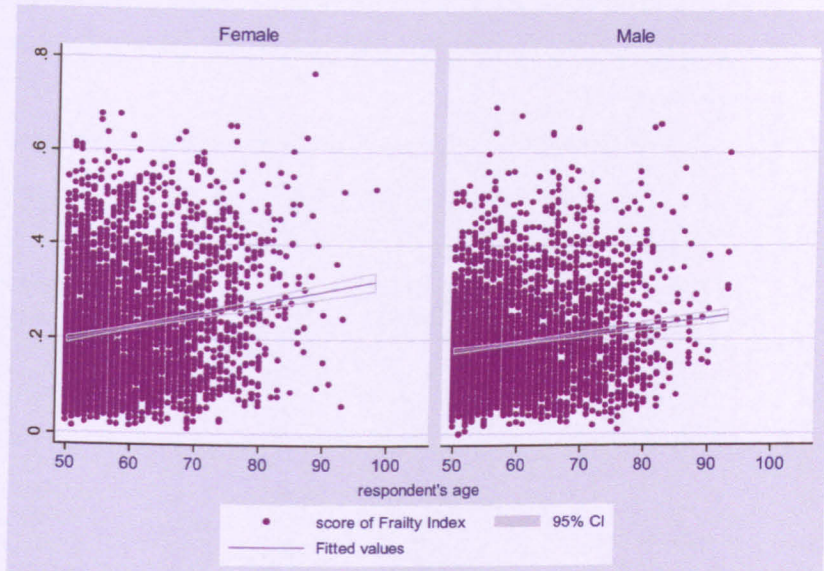
Differences in the mean scores of men and women are also clearly observed in Figure 4.2. While the scores for men appear more “compressed” around the mean, the numbers for women present a much wider spread.

Figure 4.2 Histogram of Frailty Index, by sex



The results for the plots of the frailty index scores by age, for men and women (Figure 4.3) present an alternative way of exploring the differences in their results. The fitted values of the regression estimates of the effects of age on the frailty index were added to this figure.

Figure 4.3 Scatter-plot of mean Frailty Index score, by sex and age



Women appear to accumulate higher number of deficits and therefore present higher scores from much earlier stages than men. For men accumulation of deficits appears more widespread through the age cohort. In addition, it is interesting to see how there appears to be a much higher concentration of women with frailty score over 0.4 at all ages than there is for men. This would imply that at all ages, and even early in the ageing process women, on average, have already accumulated a much higher number of deficits than men.

The regression results show there is a positive linear trend between age and frailty. The slope of the fitted frailty outcomes for women appears to be steeper than the slope for men. This indicates that the rate of accumulation of frailty by women occurs at a higher rate than for men. For each year the increase in frailty (or additional frailty accumulated) by women is 0.0035 and 0.0027 for men. The difference of the mean score between men and women is large (0.223 for women, 0.195 for men) and statistically significant ($p=0.0001$).

Analyses of mean frailty scores according to several socio-economic and demographic characteristics indicate some important differences. These were first observed in the mean score difference between groups and the results of the Kruskal-Wallis tests.

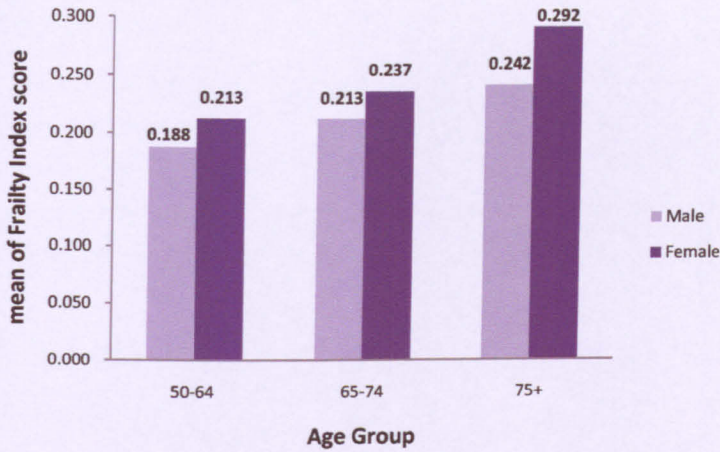
The second analysis generated was to explore differences in score by individual's age. Looking at the mean ranks (Table 4.4), we can see that the group 65-74 years old has the highest rank and the difference between groups is significant ($p=0.001$).

Table 4.4 Kruskal-Wallis non-parametric test of the difference between ranks

Ranks	N	Rank sum	Chi-square	Degrees of freedom	Probability
sex			67.087	1	0.0001
female	3525	1.27E+07			
male	3285	1.05E+07			
age group			96.801	2	0.0001
50-64	3635	1.17E+07			
65-74	2065	7.21E+06			
75+	1110	4.29E+06			
income			72.829	4	0.0001
quintile 1	1388	4.67E+06			
quintile 2	983	3.56E+06			
quintile 3	1302	4.78E+06			
quintile 4	1496	5.05E+06			
quintile 5	1636	5.10E+06			
education			221.35	2	0.0001
no formal education	1088	4.25E+06			
up to primary	3691	1.30E+07			
up to secondary	2031	5.89E+06			
civil status			174.861	1	0.0001
single, divorced, widowed	1964	7.66E+06			
married/in union	4846	1.55E+06			
work status			102.225	1	0.0001
has work outside home	3399	9.24E+06			
does not work outside home	2410	7.64E+06			

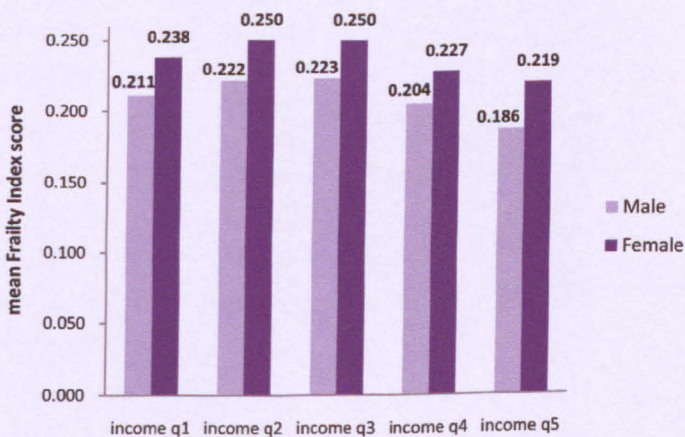
In addition, the mean scores indicate that while the difference between men and women in the groups aged 50-64 and 65-74 years old is similar, this gap or difference among them becomes noticeably different in the group 75 years and older. Figure 4 also shows there are significant differences among the three age groups.

Figure 4.4 Frailty Index, by sex and age group



Another factor that appeared to differ significantly among groups was individual income ($p=0.0001$). As it can be noted in Figure 4.5, for men and women that fall in the first two quintiles of income, as income increases mean frail score also increases, thus, they are frailer. This trend appears to stabilise when reaching the third income quintile when it starts to decrease. It is clear that those in the highest income quintile present the lowest frailty. In addition, it is very important to observe that through all income quintiles, the differences between men and women persist. The largest difference between men and women appears in the highest income quintile.

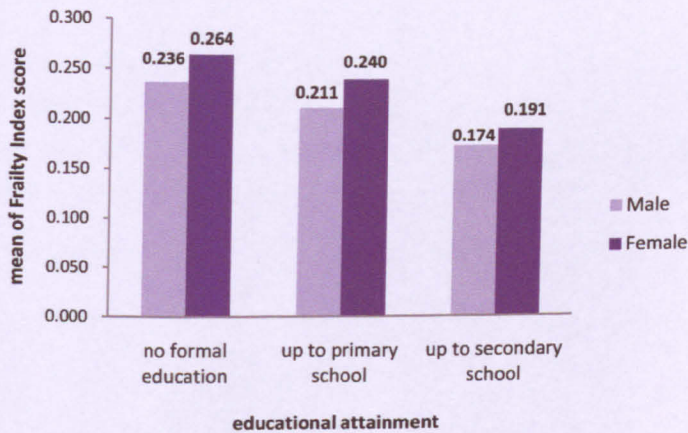
Figure 4.5 Frailty Index, by sex and income quintiles



In the general literature, educational attainment has been showed to be a relevant determinant of overall health and wellbeing. The analysis of the frailty scores according to the three main educational outcomes reported in this sample shows that there are important and significant differences among them ($p=0.001$).

Figure 4.6 shows an apparent linear trend where as educational attainment increases, frailty is lower for men and for women. The persistent differences between men and women are large and in particular in the groups with no formal education or with completed primary school (with almost double the points difference compared to men and women who at completed at least secondary school).

Figure 4.6 Frailty Index, by sex and educational attainment



The analysis of the possible effect of civil status or partnership on frailty show that there is a statistically significant difference between single individuals (including divorced and widowed) and those who are married or living with a partner ($p=0.0001$) (Figure 4.7).

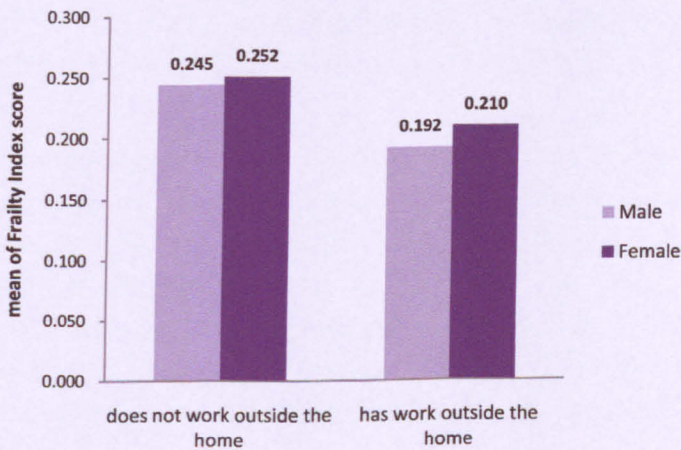
As with previous analyses, there are important differences between men and women, whether they are single or married. However, it seems that for both, having no partner or being single has the largest impact and thus this group presents one of the highest scores, e.g. frailest status. The difference among ranks test also shows a significant difference between the two partnerships/civil status groups ($p=0.001$, Table 4.4).

Figure 4.7 Frailty Index by sex and civil status



The final socio-economic factor that appears to be a strong determinant of frailty status (score mean) is the individual's condition of employment. Figure 4.8 shows how those who do not have an employment or do not work outside the home have much larger frailty scores than those who do work outside the home.

Figure 4.8 Frailty Index, by sex and condition of employment



Additional analyses were done to explore differences among size of locality (population < than, \geq 100,000), ethnicity or indigenous background, and if the individual has medical and social security insurance. Although there were differences in the scores, both between men and women and between the ranks, the tests showed these differences are not significant.

4.5 Discussion

This chapter has presented the methods and empirical application to generate a frailty index for the ageing population in Mexico. One of the main aims of this chapter was to generate the index as an individual score or indicator of frailty, but also as a group indicator of possible differences among sub-samples of the data.

The results of the frailty score show how there are statistically significant differences among some subgroups of the sample. The main differences appear to be between men and women, between income quintiles, according to educational attainment, by civil status, and by age group of the population.

Besides the differences by sex, it appears that it is those in the lowest income quintile, with no formal education, with no formal employment or that do not work outside the household, and those that are single (including divorced or widowed) who have the highest frailty scores that is, they have the frailest condition. These findings ask for a further reflection on the possible causes and consequences, as well as to investigate if the effect of each predictor is independent of the others or not.

First, it seems clear that there are important differences between men and women. This has appeared to be the case in studies of frailty, disability, and health status in different countries (Mitnitski et al., 2005; Newman and Brach, 2001; Mitnitski, Song, and Rockwood 2004; Fried et al., 2001; Rose, Hennis, and Hambleton, 2008).

Regarding the demographic indicators, as expected, as age increases, individuals appear to be more frail. Interestingly, the rate at which this happens is much faster for women than for men and therefore, women on average accumulate higher number of deficits at practically all ages. Although there is currently vast research trying to find the main causes of such differences in frail status among men and women, it appears that unequal opportunities in access to education, employment, health services, among other factors, throughout the life course are most likely factors.

The third issue relates to socio-economic factors that have previously been explored as important determinants of wellbeing of older adults. The findings here are similar to those in other studies (Alvarado et al., 2008). The fact that those in worse or more disadvantaged conditions regarding their education, income, and employment status present the higher frailty status is a major concern.

It is clear that of all the present inequalities in the country, life-course disadvantages have a large impact on how individuals go through the ageing process and their condition in later life. Thus, these results should be taken seriously by policy makers in the health, social security, and social development sectors and a priority should be to keep working to eliminate such inequalities early in life and, for those in old age already, to help them in meeting their needs and alleviating their already disadvantaged condition.

Another issue to consider is the protective effect that being married/having a partner appears to have in frailty status. This has been found in other studies on frailty (Andrew, Mitnitski, and Rockwood, 2008). This is particularly relevant in the context of the ageing Mexican population. Currently, a large proportion of the old population lives in extended family environments, and one could expect, with extensive support.

Finally, it would be very interesting to see if the appearance of frailty in Mexico occurs at a faster pace or earlier age than in other countries, especially in the context of more disadvantaged populations and the life course effects of inequalities and poverty. Although there are studies undertaken in different countries using this operational definition of the frailty index, unfortunately they would not be comparable given the samples used are for people aged 70 to 75 years and older, and this study for Mexico contemplates the full sample of the ageing population as defined by the MHAS of 50 years and older.

However in the future, given current high rates of migration, smaller/nuclear families, and more children, especially women, working outside the home this support could become scarce or significantly reduced. Therefore, the fact that having a partner/spouse appears to have such a significant effect on frailty seems to put older adults at higher risk in the future, especially those who do not have close family or extended social networks to rely on. This should also be considered in the planning of future policies so as to identify those older adults who are in a more vulnerable position.

The methods, estimations, and results of these study show clear contributions and some limitations that entail further discussion. First, by generating a *Frailty Index* this study has provided one of the first comprehensive indicators of frail status of the ageing population in Mexico. This study has also shown how significant socio-economic inequalities prevail through old age and affect the way in which each individual faces the ageing process.

Given the way it is constructed and the "deficits" that populate the index, more than an indicator of dependency or need in the older population, it seems that the most valuable aspect at this point is to show how the frailty index performs as an indicator of individual and population health. In addition, it allows for identification of vulnerable subgroups of the population when used to analyse, for example, the frailty scores by socioeconomic and demographic factors such as income, marital/partnership status, age, or locality of residence.

In this sense, it is a valuable instrument for clinicians and policy makers in identifying the most vulnerable and frail, allowing for specific treatment interventions, as well as identifying those that are pre-frail where prevention interventions would be highly valuable. In addition, it could be useful as an input or covariate in studies of other factors associated with the ageing and wellbeing of the older populations.

Notwithstanding its usefulness in clinical and strategic intervention planning, there are some aspects in which these results and the use of an indicator such as this frailty index have to be taken with caution. First, in the conceptual definition of this index, frailty is defined as a state of increased vulnerability to adverse outcomes, without placing it in a specific point within a process, but as a state presented differently in each individual. Thus, more than generating a unique way of placing frailty in the continuum of the disablement process, the index focuses on ways of understanding what each individual is going through or the way they are reflecting a specific state of vulnerability at a specific time/moment. To do so, an index reflecting how frail a person is, is generated. Thus, it is important to recognise the relevance and usefulness of such a frailty index as an analytical tool, and not necessarily as part of the ongoing conceptual discussion on the definition of frailty, disability, their relation, potential causality, and the place they each hold within the disablement process.

In addition, although the authors of the Frailty Index state that it seems that within limits, it is the amount of deficits included not the type of impairment that is included, in order to measure the defined vulnerable state, the inclusion of such a wide array of factors in the index poses some questions that should be addressed and possibly used as validation comparators in further studies. For example, the inclusion of risk factors such as smoking and drinking, with indicators of comorbidity, and with dependency such as extreme pain and urine loss, makes it hard to identify the specific role each one is having in defining vulnerability or ability of the organism to bear some adverse outcomes. This could be tested by

including different numbers and different combinations of deficits or factors in the calculation of the frailty index in future studies.

A related issue arises given that the index assigns equal weights to all the deficits included. Again, while the reasoning of the number of deficits not the type makes the operational definition of the index easier, giving such different conditions as the ones included equal weight could be questionable. However, studies that have used the index and included weighting of some deficits (Googins et al., 2005) state that the definition of the weights was done arbitrarily, which also seems delicate in terms of the results obtained and their validity. Generating a specific and local-level evaluation of the optimal weights that should be given to each deficit included in the index seems an enormous effort that should be considered by policy makers and researchers as its usefulness and viability in generating it. In absence of this, the index shows to be useful and should be included both as an individual and population health indicator, as well as for comparison with other populations.

In chapters 6 to 8 three different studies which are considered highly relevant to the older individual's life and ageing process, consider the frailty index as a means of comparison with other main predictor variables reflecting health status. These are a study of survival in the MHAS sample of study, a study of their utilisation of health services, and a third one on the supply of informal care that they receive in the household and family context.

Chapter 5 Determinants of disability in a sample of the ageing Mexican population

5.1 Introduction

As discussed in previous chapters, the conceptualisation and empirical measurement or estimation of disability in the older population is one of the most valuable paths to understanding the ageing process, the overall wellbeing of older individuals and their interaction with their social environment.

Disability was been defined by a wide number of experts in the medical and academic arenas, and an equally large array of empirical studies have been generated in order to describe and try to understand the individual process older adults go through into and out of disability.

Within the current context of rapid ageing of the Mexican population, there is still scant information available on current disability status in the older population, its determinants, and the way it affects different subgroups of the older population in the country. In order to advance knowledge on this issue, this chapter presents the results of an estimation of disability using a representative sample of the population 50 years and older in Mexico, the Mexican Health and Ageing Study.

Following the introduction, section two presents the methods used to generate the estimations of disability for this sample. The chapter then continues by describing the statistical analyses undertaken and details the data used in the estimations. Section five of the chapter presents the results of the estimations, while section six discusses the contributions and limitations of this study.

5.2 Methods

In selecting an appropriate method to estimate the disability status of the ageing population in Mexico, and its possible determinants, it is important to consider the advantages/disadvantages of different methods applied in earlier studies, as well as the reliability of the estimators and the power to explain this group's status.

As noted previously, in spite of the vast amount of empirical work on disability and health status, there is still no general agreement among researchers on the best way to measure frail and disabled status and the ageing process. In addition, a large part of the work has concentrated on physiological conditions in their intent to describe the ageing population, although it appears that comprehensive

assessments which include social components appear the best option to try for the estimations for Mexico.

From the empirical work reviewed, different methods have been used to study the prevalence and determinants or factors associated with the onset and progression of disability. Some of the most widely used methods appear to be the use of descriptive statistics of prevalence and of differences between groups (Liu, K., Manton, and Liu, 1990; Bootsma-Van Der Wiel et al., 2005). Univariate and multivariate logistic regressions are also commonly used to explore association between disability and: chronic diseases, depression, cognitive impairment, pain, and socio-demographic conditions (Ávila-Funes, Garant, and Aguilar-Navarro, 2006; Barragán-Berlanga, Mejía-Arango, and Gutiérrez-Robledo, 2007; Bello et al., 2005; Bootsma-Van Der Wiel et al., 2005; Grundy and Glaser, 2000; Mejía-Arango et al., 2007; Melzer and Parahyba, 2004). Logistic regression methods have also been used to predict general determinants of disability (Dorantes-Mendoza et al., 2007).

Regarding estimations of frailty, some studies have measured it as a score and linear regression models (univariate and multivariate) used in order to predict frailty, its association with other factors, or its determinants (Ottenbacher et al., 2005) Logistic regression analyses have also been used to predict risk of frailty, for baseline indicators and of the transition between periods (Fried et al., 2001).

Other studies of frailty have used survival analysis techniques. In some analyses, Kaplan-Meier survival curves have been used to examine differences in survival between the frail and non-frail (Puts et al 2005). In others, proportional hazards models (univariate and multivariate) have been used to predict survival (relative risk of death) given different frailty status (Kulminski et al., 2004, Ottenbacher et al., 2005, Kulminski et al., 2008) , and to assess contribution of baseline frailty to incidence of major geriatric outcomes over a period of time (Fried et al., 2001).

In selecting the methods to be used in this study on disability in the ageing population in Mexico, it was considered essential not just to add to the current work by using more complex methods that would allow not only modelling the presence or absence of disability and its determinants, but also to include the severity or level of disability. In addition, this study differs from earlier ones in Mexico using MHAS by including the whole sample from age 50 and older. This is considered important since any preventive strategies that might be formed by this study are likely to focus on this age group, not just the oldest old.

It is considered of great value to future policies and programmes for the ageing population in Mexico to have more detailed data on the determinants and factors associated to different types and levels of disability. On the one hand, to assist with the planning and provision of services, and on the other, by helping medical practitioners to focus on preventive or specific services and strategies that provide the best ad-hoc services.

Given the MHAS has an extended section on support and help from family members and its relevance in some studies' findings, and given its role in the overall status of the older population it is important to consider the inclusion of such support in the estimation of disability status in the ageing population in Mexico. This could add value to other estimations in Mexico and elsewhere. Finally, when including predictor variables such as depression and cognitive status, it seems important to choose among those models or scales that have been validated for the Mexican population.

There are two models that allow for the estimation of the probability of being disabled and for different levels of disability. Their specification and how they are defined in the study are described below.

5.3 Statistical analysis

The two econometric models chosen to study disability in a sample of the ageing population in Mexico are the bivariate probit and the ordered probit models. These models fall within the qualitative response models, that is, models where the dependent variable has a discrete rather than continuous outcome.

Bivariate probit regression models are defined by two equations for two binary outcomes that vary jointly. This model can be described as an extension of the probit model by allowing more than one equation, with correlated disturbances, in a formulation similar to the seemingly unrelated regression model (by viewing the two probit equations as a system and estimate them jointly as $\rho \neq 0$ long as) (Greene, 2008).

The general specification of the bivariate probit model is:

$$y_1^* = x_1\beta_1 + u_1, \quad y_1 = 1 \text{ if } y_1^* > 0, 0 \text{ otherwise}$$

$$y_2^* = x_2\beta_2 + u_2, \quad y_2 = 1 \text{ if } y_2^* > 0, 0 \text{ otherwise}$$

$$\begin{pmatrix} u_1 \\ u_2 \end{pmatrix} \sim N \left\{ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix} \right\}$$

Ordered probit models are defined by a dependent categorical variable with more than two categories which indicate a ranking of the responses. The categories can be ordered from high to low (or vice versa) but the distances between adjacent categories are not defined/fixed as with cardinal measures. "The numerical codes representing these categories do not matter, so long as higher numerical values mean "more" of whatever is being measured.

The specification of the ordered probit models starts with:

$$y^* = x'\beta + \varepsilon.$$

y^* is unobserved so that what is observed is:

$$\begin{aligned} y &= 0 \quad \text{if } y^* \leq 0 \\ &= 1 \quad \text{if } 0 < y^* \leq u_1 \\ &= 2 \quad \text{if } u_1 < y^* \leq u_2 \\ &\vdots \\ &= J \quad \text{if } u_{J-1} \leq y^* \end{aligned}$$

As with the binomial probit models the error ε is assumed to be normally distributed across observations.

The first step in the analysis was a descriptive exploration of the prevalence of disability in the sample and an investigation of any differences among groups of the population. Possible differences between men and women are of special interest, as are differences by several socio-demographic characteristics such as educational attainment, size of locality of residence, marital status, etc.

Depending on the nature of the independent and dependent variables the Chi-square test and the Kruskal-Wallis tests were used to explore any significant relations between selected predictor variables and the outcome variables reflecting disability in ADLs and IADLs. For the ordinal outcome variables, that is, the score of Lawton and Brody's ADL and IADL scales, Kruskal-Wallis tests were done. For the binary outcomes of having difficulties with ADLs/IADLs (1=yes), and receiving help to do this activities (1=yes), Chi-square tests were performed.

Regression analyses were then conducted in order to identify predictors of disability in ADLs and IADLs. For the ordered and bivariate probit estimations models were generated separately for men and women to explore possible differences between them regarding the determinants and level of disabilities.

Additional analyses were made by running both the ordered probit and bivariate probit models including interaction effects for those variables the coefficient were different between men and women, and to test if these differences were significant.

Thus, the sex variable was used to generate interaction variables with: use of health services (inpatient and outpatient hospital services), having had a fracture in the year previous to the survey, suffering depression, if their chronic disease(s) interfere(s) with every day activities, exercising/physical work regularly, and if the respondent drinks regularly.

Given that within the sample, individuals 50-64 years old represent an important proportion and are expected to be in better health status, the analysis were made for two age groups. One set of estimations includes the full sample of individuals 50 years and older and a second one uses a sub-sample including only respondents aged 65 years and older.

After the regression, marginal effects of the explanatory/predictor variables on the outcome variables (for an average individual) and predicted probabilities (of a particular outcome) were estimated.

Given that the intention of the studies included in the thesis is to make inferences about the population 50 years and older in Mexico, following the methods presented in Chapter 4, the models were estimated for complete-cases and full-information using the Multiple Imputation by Chained Equations, ICE method and the *mim* programme. In addition, two sets of models were estimated one using complete-case analyses only and a second set using multiple imputation techniques in order to have the full data for all observations. This is a clear advantage over previous empirical studies that only use complete-cases. Unfortunately the *mim* procedure does not allow for all the post-estimation tests otherwise available otherwise in Stata, and therefore when these are presented, they refer to the complete-case analyses only.

All the regressions were estimated using robust standard errors clustered by household in order to account for possible auto-correlation in differences within households.

5.4 Data

The study of disability status was undertaken using the Mexican Health and Ageing Survey, MHAS described in Chapter 4. As in the estimations of Frailty, proxy interviews were not included (1032 proxy interviews). Even though the interviewer can ask the proxy respondent if the older person has difficulty carrying out different activities, if they receive help in order to do them, and if so, who helps, there is a relevant number of other variables included in the models that have to be responded directly i.e. questions evaluating depression or imply specific activities i.e. section on cognitive impairment.

Given that including observations with proxy interviews that include so few covariates would imply losing them in the estimations due to missing data, it was decided to not include them in the sample. This is not done without acknowledging the possible bias this can produce. For example, by possibly leaving out some of the very frail adults, there may be an underestimation of the values of disability. However, as it was noted in Chapter 4, cases where proxies were needed due to ill health or hospitalisation, and thus the individual is presumed highly disabled or ill, are not significantly high in number. A separate analysis of those respondents who needed a proxy interview controlling by reason why the proxy was needed should be explored in future work.

The total sample used in the estimations of disability consists of 12,487 individuals (54.18% women). The average age in the sample is 62 years with a standard deviation of 9.4 years (range 50-105 years old). The description and basic descriptive statistics of the sample are presented in table 5.1.

From different sections of the survey data sets, relevant variables were selected, recoded, and merged in a master data set. Both models were estimated using the STATA10 statistical software (StataCorp, 2007)

Given the current discussion among experts on what best reflects the good/frail status in older adults, whether having difficulty with performing specific activities and/or reporting receiving assistance in order to perform them, or the need to estimate them both simultaneously, both measures are included in this study.

Dependent variables

For the bivariate probit model, disability was defined as the presence of difficulty performing specific activities ADLs or IADLs (first response variable-equation), and receiving help in order to perform these activities (second response variable-

equation). Both variables are coded 1=yes, 0=no as required in the specification of such models. ADLs included for the coding of the variable are incontinence, feeding, dressing, physical ambulation/walking, and bathing, while for the binary difficulty in IADLs variable the following tasks were included: preparing a meal, shopping for groceries, taking own medications and managing own money.

For the ordered probit disability was assessed according to a modified version of Lawton and Brody's Physical and Self-Maintenance Scale (Lawton and Brody, 1969). The modified scale for ADLs has a range of 6 levels (0-5) and includes: incontinence, feeding, dressing, physical ambulation/walking, and bathing. In the scale, 5 represents full ability to perform all activities and 0 represents an individual who is completely unable to perform such tasks, total disability.

With respect to IADLs, the scale has a range of 5 levels of ability status where 4 represents complete ability to perform the activities and 0 represents individuals completely unable to perform such tasks. The activities included in the IADL scale are: ability to prepare a meal, shopping for groceries, taking own medications and managing own money. Their descriptive statistics are included in Table 5.1.

Predictor Variables

The ordered probit and bivariate probit models were estimated using the same predictor variables. These are presented in Table 5.1 including a description and the percentage of missing values for each variable. For continuous variables, their mean value is presented, while for categorical variables the percentage falling in each category is presented.

As mentioned, the main categories or dimensions of predictor variables included were measures of health status: self-reported health, number of diagnosed chronic diseases (hypertension, diabetes, cancer, respiratory illness, heart problems: heart attack, stroke, and arthritis), interference of an illness related to the diseases with their daily activities, depression, cognitive performance, and risk factors (tobacco, alcohol, physical activity); utilisation of health services: hospital admissions, outpatient procedures, and medical visits; and socio-demographic characteristics: age, gender, marital/partnership status, formal education attainment, individual income, and access to social security/pension.

Table 5.1 Definition and main statistics of variables used in the models

Variables	Description	Obs.	Mean(SD)/ %	% Missing
Outcome Variables				
<i>Ordered Probit</i>	<i>Lawton and Broady-ADLs scale</i>			47.9
L-B ADL scale level 0	0= completely unable	34	0.27	
L-B ADL scale level 1	1	105	0.84	
L-B ADL scale level 2	2	148	1.19	
L-B ADL scale level 3	3	331	2.65	
L-B ADL scale level 4	4	1079	8.64	
L-B ADL scale level 5	5= completely able	4810	38.52	
<i>Ordered Probit</i>	<i>Lawton and Broady-IADLs scale</i>			7.39
L-B IADL scale level 0	0= completely unable	141	1.22	
L-B IADL scale level 1	1	109	0.94	
L-B IADL scale level 2	2	231	2.00	
L-B IADL scale level 3	3	462	4.00	
L-B IADL scale level 4	4=completely able	10621	91.85	
<i>Bivariate Probit</i>				
difficulties in ADLs	has difficulty performing ADLs (1=yes)	1193	15.32	0
help with ADLs	receives help to perform ADLs he/she has difficulty with (1=yes)	322	2.58	45.9
difficulties with IADLs	has difficulty performing IADLs (1=yes)	925	7.41	0
help with IADLs	receives help to perform IADLs he/she has difficulty with (1=yes)	765	6.12	0.3
Predictor Variables				
<i>Health care services</i>				
insured	has access to social security and health services (1=yes)	7721	61.83	0.1
inpatient	spent nights in hospital in previous year (1=yes)	1180	9.45	0.2
outpatient	had outpatient procedures in previous year (1=yes)	252	2.02	0.1
visited MD	visited md/specialist in previous year (1=yes)	8040	64.4	0.4
<i>Risk Factors</i>				
physical activities	performs physical activities-exercise regularly (1=yes)	4154	33.27	0.8
smokes	smokes (1=yes)	2180	17.46	
drinks	drinks regularly (1=yes)	3911	31.32	0.1
<i>Health conditions</i>				
fractures	suffered fractures in previous year (1=yes)	1584	12.69	2.07
pain	suffers from constant pain (1=yes)	5186	41.53	0.14
no. chronic diseases	No. of chronic diseases (range 0-6)	12140	0.9(0.95)	2.78
	0	5042	40.38	
	1	4240	33.96	
	2	2087	16.71	
	3	633	5.07	
	4	119	0.95	
	5	18	0.14	
	6	1	0.01	
interfere	Chronic disease(s) interfere(s) with daily activities (1=yes, 0=no)	1746	14	0
depression	classified as depressed (1=yes)	577	4.62	3.0
<i>Self-reported health</i>				
good	self-reported health: excellent, good	4600	36.84	
fair	self-reported health: fair	5840	46.77	
poor	self-reported health: poor	2042	16.35	
<i>Socio/demographic</i>				
male	male=1	5722	45.82	0
Age				0
50-64	50-64 years old	8063	64.57	
65-74	65-74 years old	2904	23.26	
75+	75 years and older	1520	12.17	
Education attainment				0
no formal education	no formal education	3110	24.91	
primary	up to primary school	6653	53.28	
secondary+	up to secondary education and higher	2724	21.81	
Marital status				0
single	single (includes divorced/separated /widowed)	3,821	30.60	
married	married/in union/partner	8666	69.40	
more urban	locality of residence has population 100,000 and more(1=yes)	8314	66.6	0
individual income	individual income	12437	5136 (58203.2)	0.4
potential care	total num. of potential female carers 12 yrs. and older	12487	0.80(0.934)	0

The data included in Table 5.1 is considered self-explanatory except for number of chronic diseases and depression for which a more detailed description is presented below.

First, the variable number of chronic diseases includes the following: diabetes, hypertension, heart attack, stroke, cancer, arthritis, pulmonary or respiratory illnesses. The variable is constructed as a simple sum of the number of diseases that an individual has and the range of the variable is from 0 to 6.

The variable on depression is constructed using the Center for Epidemiologic Studies Depression Scale¹⁷ (CES-D). The MHAS questionnaire on depressive symptoms includes 9 items. This questionnaire was assessed for validity and reliability (Aguilar-Navarro et al., 2007) and the CES-D was one of the instruments chosen for this. Given it proved to be reliable and valid for the Mexican population, the CES-D scale was also selected for this study in order to define depression in older adults. From this assessment, a cut-off at ≥ 5 points was established and followed in this study to define individuals with depression.

5.5 Results

5.5.1 Disability in performing Activities of Daily Living, ADLs

The results of the Kruskal-Wallis equality of populations rank test show that there are statistical significant differences among levels of disability in ADLs (measured by levels of the score of the Lawton and Brody ADLs scale) between those who had used hospital services (spent nights in hospital ($p=0.0001$) or had outpatient procedures ($p=0.0001$) and those who had not; those who had a fracture in the previous year; having constant pain; and for those with chronic diseases that interfere with their everyday life ($p=0.0001$). There were significant differences among those classified as depressed regarding their disability, and as expected as age reaches the oldest old stages, differences in disability are also significant ($p=0.0001$).

There is one risk factor that was statistically significant, frequent exercise or physical activities. Education was the only socio-economic indicator¹⁸ that was a significant factor of difference in disability level.

¹⁷ CES-D Scale (Department of Health and Human Services, National Institute of Mental Health) The original CES-D consists of 20 questions, www.holzerent.com/pages/forms/w/ces-depr%20scale.doc

¹⁸ The other factors tested were insurance/social security status, sex, marital status, and size of locality.

The results of running the models for men and women separately showed some differences in coefficients and their significance. However, in testing these differences with the inclusion of interaction effects, except for one case¹⁹, the interaction terms were not significant. Therefore, the results of the pooled men/women models for the sub-sample of individuals 50 years and older and 65 years and older are presented.

The results of estimating the models with robust standard errors were similar to those with conventional standard errors. The results using the robust standard errors are presented here.

Ordered Probit

The ordered probit estimation coefficients for the sample of individuals 50 years and older indicate a positive and significant impact (on the probability of being unable to perform ADLs) of: having spent days in hospital in the past year; reporting fair or bad health status (compared to those who reported good health status); and being in the highest age group (75+). This is the case for both the complete-case and the multiple imputation analyses. In Table 5.2 we can note how compared to those who self-reported good/very good health status, those who reported being in fair or poor status had a lower likelihood of being in the higher stages of the scale, that is, having no difficulties and being perfectly able to perform all ADLs.

Having had an outpatient procedure performed in the last year is significant when considering the full sample of people 50 years and older for the complete-case analysis, after the multiple imputation, this coefficient ceased to be significant. On the other hand, while a fracture in the past year appears to be significant only for those 65 years and older in the complete-case analyses, they are highly significant when using the multiple imputed data. Thus, those who had fractures in the past year are much less likely to be in a higher score of the scale meaning and less able.

¹⁹ This was the case for the interaction male*fractures in the ordered probit models for the sub-sample of individuals 65 years and older. Given the higher prevalence of fractures in women in general, this result was not expected. The interaction coefficient was positive and significant. One way to interpret this finding is that although less in number, when men suffer fractures they are more severe and cause higher difficulties which also require a larger amount of help or support.

Table 5.2 Ordered Probit model of the determinants of disability according to Lawton and Brody's scale of difficulty with ADLs

Variable	Complete-Case Analyses				Multiple Imputation Analyses			
	age 50+		age 65+		age 50+		age 65+	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
lb_adi								
insured	-0.011	0.847	0.100	0.216	0.004	0.897	0.077	0.104
inpatient	-0.261	0.000	-0.148	0.111	-0.011	0.000	-0.016	0.001
outpatient	-0.459	0.001	-0.245	0.130	-0.020	0.280	-0.004	0.798
visited MD	-0.016	0.788	0.047	0.571	-0.001	0.568	-0.001	0.983
fractures	-0.164	0.011	-0.251	0.002	-0.207	0.000	-0.190	0.000
pain	-0.123	0.023	-0.112	0.132	-0.187	0.000	-0.128	0.005
physical activities	0.186	0.001	0.360	0.000	0.155	0.000	0.300	0.000
smokes	0.007	0.898	-0.063	0.428	0.018	0.655	0.008	0.897
drinks	0.098	0.091	0.224	0.008	0.048	0.190	0.045	0.436
fair self reported health ^Δ	-0.230	0.002	-0.312	0.004	-0.115	0.004	-0.167	0.008
poor self reported health ^Δ	-0.580	0.000	-0.618	0.000	-0.441	0.000	-0.478	0.000
no. chronic diseases	-0.070	0.017	-0.072	0.082	-0.088	0.000	-0.055	0.045
interfere	-0.299	0.000	-0.258	0.005	-0.330	0.000	-0.300	0.000
depression	-0.399	0.000	-0.481	0.000	-0.317	0.000	-0.317	0.000
male	-0.148	0.010	-0.156	0.060	-0.148	0.000	-0.170	0.000
more urban	-0.009	0.869	-0.069	0.380	-0.411	0.226	-0.115	0.019
65-74 [◊]	-0.084	0.168			-0.230	0.000		
75+ [◊]	-0.377	0.000	-0.274	0.000	-0.582	0.000	-0.330	0.000
primary [*]	0.021	0.718	0.013	0.865	0.290	0.462	-0.027	0.582
secondary [*]	0.211	0.014	0.111	0.413	0.101	0.059	0.106	0.224
single [∞]	-0.021	0.714	0.021	0.790	-0.007	0.838	-0.015	0.750
/cut1	-3.530		-3.458		-3.866		-3.520	
/cut2	-2.895		-2.837		-3.260		-2.914	
/cut3	-2.540		-2.442		-2.900		-2.532	
/cut4	-2.043		-1.975		-2.427		-2.101	
/cut5	-1.252		-1.212		-1.552		-1.270	
Observations	2722		1279		12479		4403	
Min. degrees of freedom					42.9		28.2	
Wald chi2(22)	395.32	Wald chi2 (21)	197.92					
Prob.>chi2	0.000		0.000					
Log likelihood	-2187.787		-1203.304					
Pseudo R2	0.0829		0.0758					
Imputations					10		10	

Reference categories: ^Δ good/excellent self-reported health; [◊] 50-64 years old; ^{*} no formal education; [∞] single (including divorced and widowed)

It is interesting to note how the number of chronic diseases an individual has does not seem to be significant (although the coefficient shows the expected sign showing how increasing number of diseases, decreases the chance of being in the higher levels of the scale, i.e., perfectly able), while having those chronic diseases that interfere with daily activities has a large coefficient which is statistically

significant for the two age samples and in both the complete-case analyses and full information data using multiple imputation.

Another factor turned out to be highly significant in both age samples for the complete-case and multiple imputation analyses is being classified as depressed. The negative coefficients show (Table 5.2) how for the four models, being depressed has a negative impact on disability and significantly decreases the likelihood of being in a higher/more able score of the scale. In addition, these coefficients show some of the highest numbers just after poor self-reported health.

Regarding "risk factors", performing physical work regularly shows the expected sign acting as "protective effect" on disability and the coefficient is statistically significant in both the complete-case and multiple imputation analyses. Interestingly, this has a larger effect for the sample of 65 years and older although it is highly significant for the two age samples.

With respect to the other two risk factors: smoking and drinking alcohol, they don't seem to be significant in terms of their effect on an individual's ability to perform ADL, this is the case for the complete-case and multiple imputation analyses.

It is important to note that aside from the highest age group (75+), only two covariates seem to be significant and only when using full-information data. These are being male and single (including divorced and widowed) which appear to decrease the probability of being in the higher levels of the scale.

The rest of the socio-demographic variables turned out not significant and do not seem to have an important effect. Still, the sign of some of the variables could be as expected such as the fact that being more educated seems to offer higher "protection" on ability to perform ADLs.

The predicted probabilities of being in each level of disability for both age groups are presented in Table 5.3. What we can see from this sample is that a large percentage of individuals is still in perfectly able conditions (level 5). From table 4 it is clear how at older ages the probability of being in the first levels of disability (more difficulties in performing ADLs) increases. In Table 5.3 we can see how 74% of the sample falls into the highest rank of perfectly able (no difficulties). Taking into account just the sub-sample of 65 years and older this probability decreases to 68%.

Table 5.3 Predicted probabilities for disability in ADLs

	50 years and older			65 years and older		
	<i>Pr</i>	<i>Confidence Interval</i>		<i>Pr</i>	<i>Confidence Interval</i>	
$Pr(y=0 x)$	0.0017	0.0006	0.0028	0.0033	0.0009	0.0057
$Pr(y=1 x)$	0.009	0.0038	0.0143	0.0147	0.0052	0.0241
$Pr(y=2 x)$	0.0151	0.0099	0.0204	0.0263	0.0158	0.0368
$Pr(y=3 x)$	0.0478	0.0376	0.0581	0.0638	0.047	0.0807
$Pr(y=4 x)$	0.1817	0.1614	0.2021	0.2097	0.1798	0.2396
$Pr(y=5 x)$	0.7445	0.7272	0.7619	0.6822	0.6549	0.7096

The results of the marginal effects for the ordered probit models are presented next. For the ordered probit models, holding all other predictor variables constant at their mean, the marginal effects show the effect that a predictor variable has on the probability of being in each outcome.

Using the full sample estimations (50 years and older) we can see that although the probability of being in the first outcome of highest disability in performing ADLS (outcome 0), are small (0.17% of the sample), some effects are significant. The most significant are self-report of poor health (0.5%), being classified as depressed (0.37%), having had same-day outpatient procedures in hospital (0.48%), and being 75 years and older (0.3%), showing the largest effects. These are followed by chronic diseases interfering with everyday activities (0.20%).

Comparing this with the mid and highest levels, as people are more able or completely able, we note the following. At outcome 3 (fourth level) 4.8% of the total sample fall in this category. Here, auto-report of poor health appears to have the largest effect (5.23%), followed by having had outpatient visits to hospital (surgery/other procedures) (4.43%), being classified as depressed (3.73%), and being 75 years or older (3.37%). It is noteworthy to see how physical activities/regular exercise and having and education of at least secondary school have such a positive effect. The impact of physical activity leads to a 1.43% lower probability of being in this category, while the probability given an education of secondary or more is of 1.56% lower.

Finally, the probability of being in outcome 5, perfectly able is of 74.45%. Here, the most determinant factors are all of negative sign. Thus, self-report of poor health status (20%), outpatient procedures (16.5%), being classified as depressed (14.1%), being 75 years and older (13%), and having chronic diseases

consequences which interfere with their daily activities (10%) lead to a lower probability of falling into this category of "perfectly able".

For the sub-sample of individuals 65 years and older, their probability of being in the lowest category (outcome 0-completely unable) is still small, and again self-reports of poor health and depression show the larger effects. For this group, the probability of being in the third outcome (mid-level of ability) increases to 6.4% with poor self reported health (6%) and classified as depressed (5%) leading to a higher probability of having this outcome.

Finally, for those in the highest level or completely able, poor self-reported health (22.8%), depression (18.36), being 75 years and older (9.9%), consequences of chronic diseases interfering with everyday activities (9.4%), fractures (9.2%) and outpatient procedures (9%) all lead to a lower probability of being in the most able category. On the other hand, frequent physical work/exercise (12.2%), higher educational attainment, and having visited a physician/medical doctor all increase the probability of being in the most able group.

Bivariate probit

The estimates for the complete-case and multiple imputation regression models are presented in Table 5.4. Most of the coefficients in the bivariate probit models have the expected signs. Utilisation of services seems to predict having difficulty with performing ADL. Having spent days in hospital is significant in both the complete-case and multiple imputation estimations but only when considering the full sample of people 50 years and older. Having had outpatient procedures seems significant but ceases to be the case in the results of the multiple imputation estimations.

Regarding health variables, suffering pain, and a higher number of chronic diseases are predictive of having difficulties with ADLs and have statistically significant coefficients in the complete-case and multiple imputation analyses but only when considering the full sample of 50 years and older. Having chronic diseases interfere with the respondents' daily activities turns to be predictive of having difficulties with ADLs with the exception of the sample 65 years and older when using complete-case estimations.

Indicators of fair or poor self-reported health appear to be highly significant in predicting having difficulties with ADLs in the complete-case and multiple estimations and for the two age samples used. As in the ordered probit models, self-reported health coefficients present some of the highest numbers showing the relevance of their effect.

Table 5.4 Bivariate Probit model of the determinants of disability according to having Difficulties with ADLs and help received to do them

Variable	Complete-Case Analyses				Multiple Imputation Analyses			
	age 50+		age 65+		age 50+		age 65+	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
<i>Difficulties with ADLs</i>								
insured	0.033	0.586	-0.083	0.334	0.012	0.763	-0.080	0.165
inpatient	0.238	0.001	0.157	0.119	0.009	0.003	0.013	0.014
outpatient	0.501	0.002	0.246	0.237	0.037	0.254	-0.034	0.646
visited MD	0.010	0.868	-0.091	0.315	-0.001	0.737	-0.002	0.480
fractures	0.135	0.048	0.228	0.011	0.224	0.000	0.218	0.001
pain	0.162	0.004	0.182	0.022	0.130	0.001	0.133	0.013
physical activities	-0.141	0.020	-0.300	0.002	-0.109	0.008	-0.342	0.000
smokes	0.003	0.947	0.083	0.339	0.026	0.610	0.049	0.539
drinks	-0.075	0.209	-0.206	0.022	-0.025	0.575	-0.378	0.577
fair self -rep health	0.237	0.002	0.312	0.004	0.155	0.002	0.229	0.002
poor self rep health	0.553	0.000	0.592	0.000	0.451	0.000	0.507	0.000
no. chronic diseases	0.096	0.002	0.103	0.020	0.090	0.000	0.060	0.045
interfere	0.244	0.001	0.177	0.075	0.302	0.000	0.273	0.000
depression	0.309	0.003	0.378	0.009	0.365	0.000	0.357	0.000
male	0.166	0.007	0.186	0.035	0.179	0.000	0.200	0.001
more urban	-0.013	0.821	0.0159	0.851	0.023	0.566	0.093	0.108
65-74	0.056	0.385			0.120	0.006		
75+	0.357	0.000	0.293	0.000	0.430	0.000	0.284	0.000
primary	-0.047	0.458	-0.007	0.993	-0.007	0.862	0.009	0.864
secondary	-0.254	0.004	-0.105	0.449	-0.139	0.023	-0.141	0.140
single	0.063	0.314	0.005	0.951	0.010	0.790	0.013	0.813
cons	-1.272	0.000	-1.272	0.000	-1.528	0.000	-1.360	0.000
<i>Help Received</i>								
insured	-0.028	0.786	-0.102	0.424	-0.063	0.328	-0.071	0.387
hosppday_d	0.356	0.002	0.304	0.037	0.015	0.000	0.021	0.000
oprocd_u	0.358	0.126	0.315	0.269	0.055	0.057	0.094	0.017
mdvis_du	0.019	0.867	-0.037	0.798	0.005	0.044	0.002	0.532
fractures	0.308	0.003	0.397	0.002	0.321	0.000	0.303	0.000
pain	0.109	0.260	0.007	0.956	0.062	0.334	-0.028	0.733
physwk	-0.314	0.017	-0.338	0.060	-0.316	0.000	-0.417	0.001
smoknow	-0.297	0.011	-0.263	0.071	-0.300	0.010	-0.232	0.111
drinks_du	-0.222	0.078	-0.215	0.177	-0.194	0.024	-0.186	0.115
du_srh2	0.210	0.166	0.352	0.099	0.193	0.053	0.183	0.160
du_srh3	0.440	0.008	0.600	0.008	0.486	0.000	0.475	0.001
chrdis_n	0.047	0.339	0.070	0.253	0.068	0.034	0.077	0.056
interf	0.274	0.020	0.263	0.065	0.321	0.000	0.362	0.000
depression	0.108	0.497	0.135	0.493	0.354	0.000	0.355	0.000
male	-0.063	0.550	-0.044	0.731	-0.056	0.428	-0.090	0.309
murb	0.016	0.893	0.264	0.058	0.109	0.117	0.257	0.004
du_age12	0.090	0.446			0.166	0.025		
du_age13	0.467	0.000	0.390	0.001	0.634	0.000	0.449	0.000
du_edlevel2	0.050	0.626	0.038	0.753	0.091	0.156	0.080	0.305
du_edlevel3	-0.113	0.507	-0.526	0.048	0.065	0.528	-0.080	0.580
single	0.290	0.004	0.356	0.005	0.157	0.012	0.198	0.018
potential carers	0.132	0.004	0.157	0.009	0.091	0.000	0.135	0.000
_cons	-2.412	0.000	-2.599	0.000	-2.831	0.000	-2.730	0.000
athrho	0.944	0.000	0.936	0.000	0.969	0.000		
ρ	0.737		0.733					
No. Observations	2809		1317		6582		4403	
Min. degrees - freedom					875.9		297.5	
Wald chi2(45)	414.20	(43)	225.93					
Prob>chi2	0.000		0.0000					
Log Pseudo-likelihood	-1776.29		-950.95					
Likelihood-ratio test of rho=0								
chi2(1)=	157.94		95.49					
Prob.>chi2=	0.0000		0.000					
Imputations					10		10	

Interestingly, while fractures did not appear as a significant predictor of having difficulties in the complete-case analyses, they turn out to be highly significant when the full information using multiple imputation is used. This is the case for the two age samples used.

In addition, suffering constant pain is significantly increases the likelihood of having difficulties when considering the sample of individuals 50 years and older, both in the complete-case and multiple imputation analyses.

From the results, it appears that some characteristics may be “protective” in terms of having difficulties. These are performing physical activities regularly, being in the highest formal education level (high school and more). On the other hand, being single increases the likelihood of having difficulties, for which we could say that compared to those with no partner, being married or having a partner also has a “protective” effect.

Being in the highest age group is highly predictive of having difficulties and as with previous results, being classified as depressed present large significant coefficients and high statistical significance, thus increasing the likelihood of having difficulties with ADLS. This is true for the two age samples included in the study and using both complete-case and multiple imputation estimations.

Finally, it is interesting to see how with the exception of the complete-case analysis of the 65 years and older sample, being male significantly increases the likelihood of having difficulties.

The second equation of the bivariate probit model presents the characteristics that predict receiving help when the respondent has difficulties in performing ADLs. Although most of the signs of the coefficients are as expected, in comparison to the equation describing difficulties, fewer variables seem to have a high predictive value.

For the sample of respondents 50 years and older, we find statistically significant coefficients for having spent days in hospital, reporting poor health, having suffered from fractures in the past year, and being in the highest age group. This is true in the complete-case and multiple imputation estimations.

In the sub-sample 65 years and older, variables that came up statistically significant in predicting receiving help in both complete-case and multiple imputation estimations were having suffered fractures in the past year, poor self-reported health, and being in the highest age group (75 years and older); while

having spent days in hospital was only significant in the multiple imputation estimations only.

Regarding the sign of the coefficients, being insured, performing physical activities regularly, and having formal education of high school and more seem to decrease the probability of receiving help.

Similarly, being married or having a partner, compared to being single also appears to decrease the probability of receiving help. However, the coefficients for physical activity are only significant in the multiple imputation estimations while being single is only statistically significant for the complete-case analyses.

The inclusion in the second equation (probability of receiving help) of an explanatory variable reflecting the existence of potential carers in the household (women aged 12 years and older) shows interesting results. For both age samples, and in the complete-case and multiple imputation estimations, coefficients are large and statistically significant showing that, as hypothesised, the availability of women in the household increases significantly the probability of receiving help.

According to the specification of the bivariate probit models, the parameter ρ measures the correlation between the error terms of the distribution of the two equations. Under the null hypothesis that $\rho=0$, the model will consist of independent probit equations which may be estimated separately (Greene 2008).

As it can be noted from Table 5.4, for this model of disability in ADLs and receiving help, the estimated value of the ρ coefficient is large, positive, and statistically significant, indicating that the two equations are directly dependent and therefore it is best to estimate them jointly as it was done here and not in two separate probit equations.

Looking at the conditional probabilities of most relevance, we note the probability of receiving help to perform activities of daily living conditional on having difficulties is of 7.36% for the sample 50 years and older and 9.5% for the sub-sample 65 years and older.

In the samples 50 years and older the predictors that have the largest effect on the probability of being in this group (that increase the probability of falling into this group/outcome) are: being in the oldest age group (75+) (6%), inpatient hospital services (4.8%), and fractures (4.7%).

The two last factors are usually related with high need of post-intervention care or impaired mobility in the individual and thus expected to both cause disability (temporal or long-term) and high needs for care.

5.5.2 Disability in Instrumental Activities of Daily Living, IADLs

Ordered Probit

The estimations of the ordered probit models model are presented in Table 5.5. As before, four models were estimated, for a full sample 50 years and older and for a sub-sample 65 years and older, and each was estimated using complete-case and multiple imputation estimations. Similar to the results for the model on ADLs, disability in IADLs for both age samples appears to be determined by having had a fracture in the past year, suffering constant pain, and reporting fair or poor health. The significant coefficient results for these covariates can be seen in both the complete-case and the multiple imputation estimations. Use of hospital services on the other hand is only significant when the full sample of 50 years and older is peroconsidered.

Table 5.5 Ordered Probit model of the determinants of disability according to Lawton and Brody's scale of difficulty with IADLs

<i>lb_iadl</i>	Complete-Case Analyses				Multiple Imputation Analyses			
	age 50+		age 65+		age 50+		age 65+	
	<i>Coefficient</i>	<i>p-value</i>	<i>Coefficient</i>	<i>p-value</i>	<i>Coefficient</i>	<i>p-value</i>	<i>Coefficient</i>	<i>p-value</i>
insured	-0.0005	0.993	-0.037	0.692	0.054	0.189	0.025	0.656
days in hospital	-0.334	0.000	-0.267	0.017	-0.017	0.000	-0.024	0.000
outpatient procedures	-0.200	0.242	-0.232	0.246	0.003	0.829	0.007	0.660
visited MD	-0.067	0.385	-0.101	0.314	-0.005	0.001	-0.004	0.138
fractures	-0.238	0.002	-0.216	0.031	-0.236	0.000	-0.202	0.001
pain	-0.193	0.006	-0.269	0.005	-0.184	0.000	-0.208	0.000
physical activities	0.273	0.000	0.524	0.000	0.290	0.000	0.460	0.000
smokes	0.157	0.025	0.169	0.082	0.177	0.004	0.193	0.023
drinks	0.335	0.000	0.355	0.001	0.152	0.003	0.219	0.003
self-rep. health-fair ^Δ	-0.357	0.000	-0.186	0.130	-0.202	0.000	-0.161	0.033
self-rep. health-poor ^Δ	-0.700	0.000	-0.553	0.000	-0.582	0.000	-0.513	0.000
no. chronic Dis. 0-9	-0.046	0.212	-0.025	0.606	-0.052	0.017	-0.018	0.518
interfere	-0.440	0.000	-0.453	0.000	-0.421	0.000	-0.450	0.000
depression	-0.341	0.003	-0.423	0.008	-0.295	0.000	-0.302	0.000
male	0.094	0.169	0.205	0.028	0.088	0.043	0.128	0.026
more Urban	-0.082	0.266	-0.013	0.145	-0.159	0.000	-0.223	0.000
65-74 [◊]	-0.254	0.001			-0.331	0.000		
75+ [◊]	-0.703	0.000	0.443	0.000	-0.879	0.000	-0.528	0.000
primary education [*]	0.140	0.054	0.160	0.079	0.135	0.001	0.160	0.003
secondary+ [*]	0.227	0.029	0.327	0.023	0.220	0.001	0.213	0.018
single [∞]	-0.050	0.484	-0.043	0.638	-0.012	0.754	-0.044	0.397
/cut1	-3.307		-2.304		-3.350		-2.950	
/cut2	-2.997		-1.977		-3.030		-2.628	
/cut3	-2.593		-1.576		-2.631		-2.222	
/cut4	-2.191		-1.205		-2.130		-1.733	
No. Observations	4726		1744		12413		4403	
Min. degrees of freedom					411.0		297.5	
Wald chi2(22)	491.07	(21)	286.32					
Prob>chi2	0.0000		0.0000					
Log pseudo-likelihood	-1317.9889		-805.0202					
Pseudo R2	0.1890		0.1567					
Imputations					10		10	

Reference categories: ^Δ good/excellent self-reported health; [◊] 50-64 years old; ^{*} no formal education; [∞] single (including divorced and widowed)

For the two age samples, underlying conditions such as chronic diseases interfering with instrumental daily activities decrease the probability of falling in the highest levels of the score (completely able). The large coefficients for the interfere covariate are one of the largest and for all models, statistically significant.

It is of high relevance that as with ADLs, depression turns out to be a large and highly significant indicator. Thus, being classified as depressed significantly decreases the likelihood of being in the high levels of the IADL scale. This is true for

the two age samples considered in the study and for both the complete-case and multiple imputation estimations.

Finally, it is interesting to see how after performing multiple imputation, educational attainment appears to be a significant predictor acting as “protective” by increasing the likelihood of being in the higher levels of the IADL scale.

Table 5.6 Predicted values after ordered probit Lawton and Brody IADL scale

	50 years and older			65 years and older		
	<i>Pr</i>	<i>Confidence</i>	<i>Interval</i>	<i>Pr</i>	<i>Confidence</i>	<i>Interval</i>
Pr(y=0 x)	0.0015	0.0007	0.0023	0.0058	0.0029	0.0088
Pr(y=1 x)	0.0025	0.0014	0.0036	0.0082	0.0043	0.0122
Pr(y=2 x)	0.0083	0.0057	0.0108	0.0222	0.0147	0.0298
Pr(y=3 x)	0.0021	0.0159	0.0244	0.0409	0.0305	0.0513
Pr(y=4 x)	0.9676	0.9612	0.974	0.9228	0.9081	0.9375

When looking at the predicted probabilities of being in each of the levels of the scale, compared to ADLs, it appears that for both age samples the probability of falling into the completely able (to perform IADLs) category is much higher, as it can be seen in Table 5.6.

The marginal effects of the ordered probit model of disability in IADLs show that the predictors that have the largest positive effect of an individual falling in the first outcome (completely unable) are poor self-rated health status, having 75 years or more, the fact that chronic diseases interfere with every day activities, being classified as depressed and, for the sub-sample 65 years and older use of inpatient hospital services also.

On the other extreme of the score being 75 years and older (8.2%), poor self reported health (7.8%), classified as depressed (3.3%), and the fact that chronic diseases interfere with every day activities, significantly decrease the probability of an individual falling in the completely able category.

Bivariate probit

The results for the bivariate probit model of disability in performing IADLs and receiving help to do them are presented in Table 5.7. Use of inpatient hospital services are positive and statistically significant when the full sample 50 years and older is considered, but not for the 65 years and older sub-sample in the complete-case analyses, while significant for both age samples in the multiple imputation estimations

As in previous results, for the two age samples, the coefficients for having had fractures, suffering from constant pain and the fact that chronic diseases interfere in everyday activities are large and statistically significant determinants of having difficulty in performing IADLs. This is true for the two age samples and both the complete-case and multiple imputation estimations.

With the exception of the multiple imputation estimations for the 65 years and older sub-sample, reporting fair or poor health is a positive and statistically significant determinant of having difficulty in performing IADLs. Thus, as health is lost or becomes worse, the likelihood of having difficulties increases compared to those who report good/very good health status. As expected, in all the models we observe that as age increases, the likelihood of having difficulty performing IADLs is higher. Together with poor self-reported health and having chronic diseases interfere with every day activities, being in the older age group present the coefficients with the larger effect in the model.

With respect to socio-economic predictors included in the model, it appears that for both age samples, none is a strong determinant of having difficulties with IADLs when using complete-case estimations. In the case of the models using multiple imputation, being male decreases the likelihood of having difficulties (both age samples), while living in more urban areas increases this likelihood (both age samples). In addition, having higher educational attainment compared to those with no formal education, appears to decrease the likelihood of having difficulties when taking into account the full sample of individuals 50 years and older.

On the other hand, for the two age samples, and using both complete-case and multiple imputation estimations, doing regular exercise or physical work has a negative statistically significant coefficient. This appears to have a protective effect by decreasing the probability of having difficulty in performing IADLs.

Table 5.7 Bivariate Probit model of the determinants of disability according to having difficulties with IADLs and help received to do them

Variable	Complete-Case Analyses				Multiple Imputation Analyses			
	age 50+		age 65+		age 50+		age 65+	
<i>Difficulties with IADLs</i>	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
insured	-0.023	0.747	-0.062	0.515	-0.066	0.132	-0.080	0.185
hospsday_d	0.323	0.000	0.236	0.038	0.017	0.000	0.025	0.000
oproc_du	0.270	0.097	0.530	0.010	0.004	0.796	0.007	0.685
mdvis_du	-0.060	0.430	-0.089	0.379	0.003	0.084	0.001	0.994
fractures	0.283	0.000	0.321	0.001	0.281	0.000	0.254	0.000
pain	0.207	0.002	0.300	0.001	0.190	0.000	0.212	0.000
physwk	-0.210	0.004	-0.377	0.001	-0.237	0.000	-0.380	0.000
smoknow	-0.152	0.028	-0.180	0.069	-0.160	0.011	-0.156	0.075
drinks_du	-0.334	0.000	-0.382	0.000	-0.192	0.000	-0.279	0.000
du_srh2	0.303	0.001	0.081	0.502	0.204	0.000	0.135	0.078
du_srh3	0.656	0.000	0.432	0.002	0.602	0.000	0.519	0.000
chrdis_n	0.035	0.328	0.030	0.520	0.050	0.029	0.032	0.294
interf	0.433	0.000	0.411	0.000	0.412	0.000	0.419	0.000
depression	0.288	0.011	0.326	0.031	0.305	0.000	0.297	0.000
male	-0.126	0.062	-0.240	0.010	-0.173	0.000	-0.226	0.000
murb	0.065	0.368	0.075	0.425	0.164	0.000	0.194	0.001
du_age12	0.211	0.005			0.325	0.000		
du_age13	0.560	0.000	-0.350	0.000	0.700	0.000	0.354	0.000
du_edlevel2	-0.175	0.015	-0.156	0.085	-0.143	0.001	-0.146	0.013
du_edlevel3	-0.204	0.049	-0.224	0.131	-0.225	0.001	-0.133	0.161
single	0.071	0.068	0.005	0.951	0.001	0.988	0.037	0.514
cons	-2.034	0.000	-1.071	0.000	-2.179	0.000	-1.747	0.000
<i>Help received</i>								
insured	-0.077	0.319	-0.061	0.533	-0.027	0.568	0.016	0.797
hospsday_d	0.272	0.002	0.240	0.031	0.017	0.000	0.029	0.000
oproc_du	0.332	0.060	0.426	0.054	-0.018	0.513	-0.038	0.376
mdvis_du	0.047	0.579	0.062	0.554	0.005	0.007	0.003	0.225
fractures	0.067	0.416	0.086	0.422	0.151	0.005	0.111	0.108
pain	0.134	0.065	0.123	0.187	0.192	0.000	0.187	0.002
physwk	-0.373	0.000	-0.496	0.000	-0.285	0.000	-0.438	0.000
smoknow	-0.097	0.192	-0.154	0.129	-0.124	0.062	-0.123	0.186
drinks_du	-0.214	0.007	-0.266	0.013	-0.080	0.149	-0.142	0.076
du_srh2	0.275	0.005	0.277	0.030	0.120	0.041	0.117	0.149
du_srh3	0.151	0.000	0.370	0.011	0.384	0.000	0.307	0.001
chrdis_n	0.056	0.150	0.004	0.933	0.055	0.019	0.015	0.632
interf	0.363	0.000	0.448	0.000	0.384	0.000	0.459	0.000
depression	0.208	0.105	0.290	0.082	0.294	0.000	0.306	0.000
male	-0.205	0.007	-0.321	0.001	-0.217	0.000	-0.224	0.000
murb	0.011	0.884	0.073	0.456	0.107	0.027	0.134	0.042
du_age12	0.272	0.002			0.345	0.000		
du_age13	0.769	0.000	-0.504	0.000	0.831	0.000	0.468	0.000
du_edlevel2	-0.024	0.755	-0.046	0.629	-0.067	0.146	-0.092	0.132
du_edlevel3	-0.125	0.265	-0.504	0.000	-0.214	0.004	-0.230	0.028
single	0.512	0.000	0.519	0.000	0.297	0.000	0.380	0.000
potential carer	0.124	0.000	0.145	0.000	0.109	0.000	0.132	0.000
_cons	-2.111	0.000	-1.094	0.000	-2.454	0.000	-2.111	0.000
athrho	1.377	0.000	1.308	0.000	1.508	0.000	1.334	0.000
rho ρ	0.880		0.863					
Observations	5210		1963		12050		4275	
Min. degrees of freedom					963.3		883.7	
Wald chi2(45)	699.88		392.4					
Prob>chi2	0.0000		0.0000					
Log pseudo-likelihood	-1455.33		-886.659					

Likelihood-ratio test of		
rho=0		
chi2(1)	536.809	308.059
Prob>chi2	0.0000	0.0000

Regarding the second equation, receiving help to perform IADLs when difficulties are present, the model seems to explain better when the full information using multiple imputation is used. For the age sample 50 years and older, having spent nights in hospital, reporting poor health, and the fact that chronic diseases interfere with their everyday activities are all positive and statistically significant in determining the probability of receiving help for both the complete-case and multiple imputation estimation analyses. On the other hand, having spent days in hospital, fractures, constant pain, and being classified as depressed only turn out to be significant for the multiple imputation analyses.

As in previous models, performing frequent exercise or physical activities have a negative effect probably meaning that those who exercise are better fit and thus need less help. The coefficients are large and statistically significant for all the models for both age groups and using complete-case as well as multiple imputation estimations.

Interestingly, marital status has a positive and somehow significant effect on receiving help in the four models. While for individuals who are married or have a partner are less likely to receive help from some other person to perform these IADLs, being single (including divorced or separated), has a positive effect on the likelihood of receiving help compared to those who are single.

As expected, in the four models, as age increases, and in particular for those 75 years and older, the likelihood of receiving help increases.

Similar to the bivariate probit model for ADLs and help with these activities, the coefficients for the predictor variable potential carers are large. In this case their significance is higher. This is a relevant finding that should be explored more in terms of the type of activities and total time that these carers are doing.

The conditional probability of receiving help given that an individual has difficulties is 43.15%. The factors that explain the most this probability are being in the oldest age group (23.6%), and being widowed (13.5%) for the full sample.

As with the bivariate probit model for ADLs it can be noted in Table 5.7 that for IADLs the values for the ρ coefficient is large, positive, and statistically significant,

indicating that the two equations are directly dependent and therefore should be estimated jointly, and not in two separate probit equations.

5.6 Discussion

Two approaches were selected to estimate disability in a way that allowed for the exploration of the likelihood of having disabilities in ADLs and IADLs, as well as the level of disability, in a sample of the ageing Mexican population.

In order to do so, two separate models were estimated. Ordered probit models of a scale of disability in performing ADL/IADLs were generated in order to investigate the prevalence of individuals in different levels of disability as well as the main factors that determine which level or category they are in. In addition, bivariate probit models were estimated. These models allowed simultaneous investigation of two equations one for the determinants of having difficulties in performing ADL/IADLs, and a second one for the determinants of receiving help to perform such activities when need is present.

Initially, an alternative approach was considered to generate an extension of Gonzalez and Ham (2007) typology of ageing in Mexico. However, from the published work it was not possible to replicate some of the work in order to first, replicate the work and then extend it by including additional predictors in the analysis.

The results from the two econometric approaches show that in general older individuals that present "more acute" health conditions are significantly more likely to report having difficulties with ADLs and to receive help to perform such activities.

Respondents having spent days in hospital and having out-patient procedures in the past year, along with poor self-reported health status and being classified with depression are significantly more likely to report higher disability status, difficulties in performing ADLs and to receive care to perform these activities. A similar but less significant effect is generated by having a higher number of chronic diseases and by these illnesses interfering with daily activities.

It is interesting to note how being in the highest age group (which demonstrates a positive likelihood of having difficulties/disability and of receiving help) and having an educational attainment of high school or more, which reduces the likelihood of having difficulties, socio-demographic variables are significant in determining the need for care by way of disability status, and the receipt of such care. In addition, the fact that being single has a positive effect on the probability of receiving help

from their family is also worth noting especially in terms of the current trends in changing family structure and constant migration.

Depression is a highly significant determinant of reporting difficulties and of higher disability status. This suggests that this condition can play an important role in overall health and disability status in older sections of the older population. It also highlights the need to extend research on the incidence and prevalence of depression, but also on the best practices so depression can be readily diagnosed and treated.

Having suffered fractures in the year previous to the interview also was found to have important effects on disability in ADL and IADL. This result is of great relevance in future planning of strategies. There is a need to investigate the causes of such fractures, whether there are differences among groups of the population and if so, their nature.

For example, it is known that on average women suffer more fractures related to osteoporosis, while it would be relevant to see the prevalence in men and if, for example, one of the main causes was fractures due to accidents or violent incidents. It is clear that these two variants would need different planning and implementation.

Finally, also related to the impact of the work on future policies or programmes, it was interesting to see in practically all the models how exercising regularly or doing physical activities appears to have a protective effect on performing ADLs and IADLs. Given the relation of physical activities to a wide range of health conditions, this suggests that as a preventive strategy health institutions should collaborate with other institutions in order to promote increases in physical activities at all ages and improve access to infrastructure so that people effectively have the options to do so.

It was expected that insurance status would have a large impact on health status and thus, in disability status given that those who are insured have access to more health and other services. However, the results do not show this. Instead they seem to have no influence. This could reflect the low use of services, especially preventive ones that could be having a protective effect on overall health and disability status.

This chapter contributes to knowledge by being one of the few studies to explain some of the characteristics and determinants of being disabled in Mexico, and the relation between disability and specific health and socio-demographic variables. In

addition it is one of the few studies to use multiple imputation techniques in the estimations. This has allowed analysis based on the full sample, representative of the population 50 years and older in Mexico, and as a result more accurate inferences can be made.

In doing so, it may provide clinical settings and health policy makers with relevant information. For example, by identifying key factors such as fractures and depression and their large effect in suffering difficulties in performing every day activities, these actors have relevant information which they can use in the planning of prevention programmes involving exercise to keep strong bones, evaluation of households to prevent falls that could be the main cause for fractures, and the need to identify cases of depression early on in order to give them timely treatment.

The work has also some has some limitations. First, given the lower explanatory power of the equation for receipt of help in the bivariate probit model, especially for the sub-sample 65 years and older, we have to consider why this could be. It is clear that a more comprehensive analysis of data on carers, the type of care and intensity of care (time dedicated) is essential.

Secondly, although the MHAS has collected two waves of information, given that the span of time between the first one and the second one is only two years, it was not possible to carry out proper longitudinal analyses which are most important for identifying trends in the onset and progression of disability, changes in states of disability, among others. It is to be hoped that in the future there are further waves of the study that allow for this type of work.

A major aspiration is that the information generated in this study can be put together with other studies from Mexico as to provide sound inputs for the generation of strategies that better cater to the present and future needs of the older population groups in Mexico. For example, given that the scarcity of long-term care programmes in Mexico leaves the bulk of the care to be done in the household, the supply of informal care for older adults was chosen as part of the thesis, and is hoped to provide relevant information in the generation of appropriate programmes for older adults.

Chapter 6 Factors related to survival of the population 50 years and older in Mexico

6.1 Introduction

As was seen in the previous chapters, there are several socio-demographic, illness, impairment, and disability characteristics that affect the overall health, disability, and frailty status of the older population in Mexico.

Also, we have seen how there are clear differences between subgroups of this population, for example, between men and women regarding the accumulation of chronic conditions and frailty status, with women being much more disadvantaged than men. Particularly vulnerable sub-groups include men with no spouse or partner and those in the oldest age groups.

Within the related literature, there are clear indications that given the common accumulation of deficits in different conditions and/or impairments, and co-morbidity in older adults, it is unlikely that any single factor related to health status will be the sole predictor of an adverse outcome, including death (Fried et al., 1998).

Thus, in order to further advance knowledge of the relationship between health, frailty, and survival (risk and incidence of mortality) of the population 50 years and older in Mexico, a survival analysis was carried out as part of the thesis. The main aim was to investigate the effect of different covariates on overall mortality in this population group. The survival analysis additionally explores the effect of different socioeconomic and demographic characteristics as possible predictors of overall survival of this population group. It is hoped that this information becomes an indispensable input to future care practices and policies which could if needed, change this incidence.

This chapter includes the analysis and results of this investigation. The first section after the introduction presents a review of previous empirical work on survival of the ageing population. Sections three and four present the methods and data used in the study. This is followed by the results in section five and a discussion closes the chapter.

6.2 Previous empirical work

6.2.1 General

A review of the related literature on survival analysis shows how the medical and biomedical fields have benefited from this type of analysis for some time now and how it has been widely used to measure time elapsed to a particular event or outcome.

Survival analysis has been widely extended to the medical field where a response variable is measured in a span of time between an initial episode/event and the time when a final episode/event occurs. This is usually called a failure. Within the literature, failures can measure a wide variety of events such as death, recovery from an illness, discharge from hospital, and referral to home care, post-surgery outcomes, among many others.

The literature of primary interest regards survival analyses generated specifically for the older population, however since only a few were identified, a wider range of population and events have been included.

Issues explored in relation to survival or mortality rates in old age include: having difficulties with activities of daily living (Larsen, 2005), hip fractures (Lu-Yao et al., 1994), cognitive impairment (Kelman et al., 1994), frailty (Rockwood, 2005b, 2005; Mitnitski et al., 2004, 2005; Goggins et al., 2005; Cacciatore et al., 2005; Jones, Song, and Rockwood, 2004), self-rated health (Idler and Kasl, 1995), post-surgery outcomes (Kojima and Narita, 2006), the role of Body Mass Index in mortality (Mazza et al., 2007), nutritional status (Allard et al 2003).

Other studies have focused on the impact of demographic factors, social networks and social environment in survival. Examples include relations with: social vulnerability and frailty (Andrew, Mitnitski, and Rockwood, 2008), living arrangements and health care utilisation (Ho, 2008), timing of hospice referral and informal care availability (Chung, Essex, and Samson, 2008), day care service use in community-dwelling older people (Kuzuya 2006), gender differences in survival of nursing-home residents (Sund-Levander, Grodzinsky, and Wahren, 2007), among others.

Additionally, more illness-specific analyses include for example, outcome for older patients with breast cancer (Hughes et al., 2008), socioeconomic status and survival in older patients with Melanoma (Reyes-Ortiz C et al., 2006), predicting survival in older patients with heart failure (Cacciatore F. et al., 2005, Rich, Huynh,

and Rovner, 2007), and outcome of older patients with prostate cancer (Wong Yu-Ning et al., 2006). The number of such articles is vast but not presented here given that they fall outside of the main interest of this analysis which is survival in a sample of the older population in Mexico.

6.2.2 Mexico

There are numerous survival analyses in the medical field in Mexico, with most examples concentrating on survival with specific conditions including survival analysis of breast cancer (Flores-Luna et al., 2008; Miranda and Rivera, 2001), cervical cancer (Flores-Luna et al., 2000), heart transplant patients (ISSSTE, 2005), patients with cirrhosis (Rodríguez-Hernández et al., 1996), survival of patients with multiple myeloma (Ruiz-Arguelles et al., 2003), survival of patients with chronic obstructive pulmonary disease (Ramirez-Venegas et al., 2006). Of these articles, only two focused on survival of older persons. Miranda and Rivera (2001) focused on survival of breast cancer in older age, while Ramirez-Venegas, et al. (2006) studied a sample of patients with chronic obstructive pulmonary disease. No studies were found which concentrate on total survival of the older population in Mexico.

6.3 Methods

As noted above, survival analysis is concerned with measuring time elapsed to a particular event or outcome. These outcomes can refer to a single event (such as death) or multiple events (such as diagnosis, treatment, remission, relapse, etc.). The time to the event is known as survival time.

One thing that is particular to survival data is that it is very common to observe individuals for whom the outcome of interest, also called "failure", is not observed. Because these individuals are also relevant for the survival analysis they are not eliminated from the estimations but included as special cases and are said to provide "censored" data for which all that is known is that they survived for a certain length of time (Parmar and Machin, 1995).

There are different types of censoring according to the time, moment, or reason for which the individual's information is missing. Thus, the individual may be lost to follow-up, moved, present a delayed entry, or not presented the outcome of interest at the end of the study. These are called "right censoring" cases and have the characteristic of having a censored time observed which is less than the failure time, but the failure time is not observed.

One of the first methods developed to estimate the probability of individuals surviving a certain period of time was created by Kaplan and Meier (1958) as described by Marubini and Valsecchi (1995), who developed the product-limit estimator²⁰. This estimator is a non-parametric estimate of the cumulative survival distribution for a sample within a specific period of time. This method is now widely referred to as Kaplan-Meier survival curves and they represent the survivor function (probability of survival past time t) $S(t)$, against the number of days t in each particular study²¹.

Given that the probability of surviving to time t will change only at those times on which at least one individual dies, those times when there are no deaths can be overlooked when calculating the equation which can be written as:

$$S(t) = \prod_i \left(1 - \frac{d(i)}{n(i)}\right) \quad \text{where } \prod_i \text{ denotes the product of all the terms after it and until it reaches time } t.$$

It has been noted that in the field of clinical or biomedical research, in contrast to other fields where survival analysis can be used, it is very difficult to have a priori knowledge to make reliable hypotheses about the underlying theoretical survival functions. Thus, non-parametric approaches have been usually adopted to estimate and compare survival curves (Marubini and Valsecchi, 1995) (Parmar and Machin, 1995). Within non-parametric survival analysis another popular method used in the literature is the Mantel-Haenszel test or log-rank test which was originally developed for comparing two sets of proportions over several confounding factors in case-control studies, and later extended by Mantel (Mantel, 1963) to survival analysis.

²⁰ The product limit method is based on the simple consideration that in order to survive one year from the beginning of observation, the subject has to survive every day from the first to the 365th. The conditional probabilities of any given day are combined to obtain the probability of surviving a full year. The process is to accumulate step by step the probabilities of surviving each day by multiplying them, that is the probability $P(2)$ of surviving two days is $P(2)=p(1) \times p(2)$. By multiplying $P(2) \times p(3)$ we obtain the probability of surviving three days and so on up to $P(365)$. The estimated probability $P(t)$ may be graphed against time t . The resulting curve is a step function that has a new step at each distinct failure time. The survival curve starts from value one, at time zero, since all individuals start at the same entry time. The curve does not change at censored times, but censored observations influence the height of the steps by "eroding" the set of individuals at risk (Marubini and Valsecchi 1995).

²¹ The overall survival curve is considered more reliable than the individually observed conditional survival probabilities, of which it is composed. However, large jumps or long flat sections in the curves may be common. These are most likely to occur if the proportion of censored observations is large, as well as in areas in the extreme right of the curve where the number of patients still alive and being followed-up may be small. Thus, it has been noted that the tail of the survival curve, where only a few patients are at risk, is very unstable, and therefore, it is always recommended to be very careful in interpreting the tail of the curves (Parmar and Machin 1995; Marubini and Valsecchi 1995)

Another widely used method in survival analysis is the Cox proportional hazards model (Cox and Oakes, 1984). This semi-parametric method estimates how the basic risk ratio changes and assumes that the underlying hazard rate (rather than survival time) is a function of the independent variables (covariates).

The Cox proportional hazards model does not require making previous assumptions about the nature or shape of the hazard function. However, it does make other specific assumptions mainly, that the risk ratio for any variable x is constant through time, and that the survival curve for a group has to be parallel to that of the other groups and do not cross each other. Thus, the model makes no assumption about the shape of the hazard but assumes that whatever shape it has, it has to be the same for every individual in the sample under study. These assumptions have to be tested and if violated, other methods such as the Cox stratified model should be used (Cleves et al., 2008; Marubini and Valsecchi, 1995).

The Cox model takes the following form to define the hazard rate: $h_i(t) = h_0(t) \exp(x\beta)$

where $h_i(t)$ is the hazard of the event occurrence at time t for the i_{th} case; the covariate vector, x and parameter vector β only include the explanatory variables, and there are no constant terms in the estimations. As it was noted above, one of the main advantages of the Cox proportional hazards model is that the baseline hazard $h_0(t)$ is not given any previously assumed distributional form.

This baseline is referred to as the hazard function for a case whose covariates are all zero. On the other hand, covariates will have the effect of raising or lowering the hazard from the baseline by some fixed amount. Thus, $\exp(\beta_k)$ is the ratio of hazards for individuals who are a unit apart on X_k , controlling for other effects (DeMarris, 2004, Marubini and Valsecchi, 1995, Cleves et al., 2008).

6.3.1 Statistical analysis

This chapter investigates the association between different health, demographic, and socio-economic factors and mortality by undertaking survival analysis in a national sample of population 50 years and older in Mexico using the methods described below. All the analyses were done using the Stata10 (StataCorp 2007) software.

Non-parametric and semi-parametric methods were used to estimate the risk of death in a two year period, for individuals 50 years and older in Mexico.

Regarding non-parametric methods, Kaplan-Meier survival curves and hazard functions were generated to estimate the probability of survival for different groups of the sampled population. Additionally, the complementary Nelson-Aalen cumulative hazard rates were estimated and the curves plotted.

In a third step, semi-parametric proportional hazards model estimations were used. Given that the Cox regression models need to contain as few variables as possible and yet describe the data adequately (Parmar and Machin 1995) Cox regressions were estimated for each covariate separately first. Those variables that were significant were then used in multivariate estimations. For both methods, in addition to socio-demographic covariates, and health characteristics, the effect of frailty on mortality was included in the estimations.

As presented in Chapter 4, the Frailty Index is constructed from many indicators and a large number of observations have missing values for at least one of these indicators. Thus, for validation and comparison purposes, estimation of the survival models were estimated for two sets of data. One set of analyses was done using missing data or complete-case case analyses. A second data set was generated using the Multiple Imputation by Chained Equations, ICE method as detailed in previous chapters, in order to generate full information or multiple imputation estimations.

As mentioned previously, the *mim* environment allows for a wide range of data manipulation and management but currently only some of the standard post-estimation commands are available. Currently, *mim* is able to perform tests and estimates for linear combinations of the regression parameters, Wald-type hypothesis tests for groups of regression coefficients considered simultaneously, and estimates of predicted values for the units of the original datasets (Carlin, Galati, and Royston, 2008). For the present study, the only post-estimation tests available are the Wald-test of difference between groups of coefficients.

Due to these restrictions on the available post-estimation tests and the importance of testing the proportionality assumption of the Cox model estimation results as well as the overall fit of the model it was considered desirable to analyse both the complete-case data (CC) and the multiple imputed data (MI) so that a wider range of post-estimation tests could be undertaken.

Thus, for the non-parametric analysis using the Kaplan-Meier product limit estimator, analysis was done just with the complete-case data sets, while survival analysis using the semi-parametric method of the Cox proportional hazards model

was done for the complete-case and multiple imputation data sets separately. The results for the Cox proportional hazards model regressions for CC and MI are presented together so they can be readily compared. Table 1 indicates the nature and extent of the missing data.

6.4 Data

Of the 15,186 respondents to the 2001 MHAS survey, 1032 proxy interviews were dropped from the sample as most health and frailty status questions are self-assessed and therefore proxy interviews omit the most relevant information.

Additionally, given that the MHAS study includes a sample of respondents 50 years and older and their spouse regardless of age, those individuals younger than 50 years were also dropped from the sample as the focus of this study is the ageing population defined as 50 years of age and above.

The final working sample for the survival analysis consists of 11,680 individuals of which 526 died during the follow-up to the 2003 interview. Of those still alive in 2003 54.6% (6,080) are female and 45.4% (5,056) male, while within the deceased individuals 48.3% (254) were female and 51.7% men (272).

The mean age within the deceased sample is 73.6 years (SD 11.6 years) and 64.5 (SD 9.23) in the sample still alive in 2003. Reflecting the fact that more than 60% of the total population in Mexico now lives in urban areas, 65% of the population lived in localities of 100,000 people and more. Table 5.1 presents the descriptive statistics for the variables included in the analysis.

Table 6.1 Description of the variables and pattern of missing data

Variable	Obs. (n=11680)	% or mean	# Missing	% Missing
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male	5,333	45.66	0	0
age			0	0
50-59~	4,138	55.60		
60-69	4,092	64.14		
70-105	3,412	77.21		
single	3,743	32.05	0	0
education level			728	6.23
no formal education~	2,756	23.6		
completed primary ed.	5,922	50.7		
at least secondary ed.	2,274	19.47		
had health problems before age 10	1,206	10.33	869	7.44
speaks indigenous language	712	6.1	842	7.21
<i>self-reported health</i>			728	6.23
excellent~	441	3.78		
very good	3,302	28.27		
good	5,174	44.3		
fair	1,831	15.68		
poor	728	6.23		
dx hypertension	4,149	35.52	1028	8.80
dx diabetes	1,743	14.92	1025	8.78
dx cancer or tumour	209	1.96	1010	8.65
dx respiratory illness	687	5.88	1007	8.62
had a heart attack	365	3.13	1012	8.66
had a stroke	272	2.33	1017	8.71
dx arthritis- rheumatism	2,248	19.25	1015	8.69
fractures since 50th bday	1,401	11.99	947	8.11
How is vision (+glasses)			802	6.87
excellent~	318	2.72		
very good	956	8.18		
good	4,626	39.61		
fair	3,854	33		
poor	1,092	9.35		
legally blind	32	0.27		
<i>How is hearing (+hearing aid)</i>			891	7.63
excellent~	589	5.04		
very good	1,418	12.14		
good	5,974	51.15		
fair	2,266	19.4		
poor	535	4.58		
legally mute	7	0.06		
<i>During the past week you...</i>				
felt depressed	4,178	35.77	816	6.99
felt everything is an effort	4,065	34.8	835	7.15
sleep was restless	4,040	34.59	801	6.86
felt happy	8,173	69.97	835	7.15
felt lonely	3,699	31.67	817	6.99
enjoyed life	7,666	65.63	885	7.58
felt sad	4,393	37.61	823	7.05
felt tired	6,618	56.66	817	6.99
had lot of energy	4,656	39.86	872	7.47
regular exercise or hard physical work	3,616	30.96	809	6.93
smokes	1,862	15.94	729	6.24
drinks alcohol	3,374	28.89	731	6.26
<i>weight</i>	9851	69.86	1829	15.66
women	5296	66.54		
men	4555	73.72		
<i>height</i>	8416	1.611082	3264	27.95
women	4210	1.56		
men	4206	1.67		
<i>Other health problems or symptoms</i>				
swelling of feet	3,070	26.28	738	6.32
difficulty breathing	1,606	13.75	741	6.34

fainting spells/vertigo	2,624	22.47	743	6.36
intense thirst	1,924	16.47	753	6.45
severe fatigue	3,000	25.68	749	6.41
wheezing, cough	2,021	17.3	747	6.40
pain in legs while/after walking	4,750	40.67	747	6.40
stomach pain, indigestion, diarrhoea	2,184	18.7	746	6.39
involuntary loss of urine	883	7.56	748	6.40
Suffers from constant pain			735	6.29
no pain~	6,378	54.61		
mild	1,484	12.71		
moderate	1,880	16.1		
severe	1,203	10.3		
<i>Do you have any difficulties with</i>				
walking several blocks	2,810	24.06	829	7.10
sitting for about 2 hrs.	2,014	17.24	803	6.88
getting up from chair	3,094	26.49	782	6.70
to stoop, kneel, crouch	4,071	34.85	825	7.06
extending arms above shoulder level	1,267	10.85	780	6.68
pulling/pushing large objects	2,321	19.87	944	8.08
lift/carry obj. 5kg+	2,172	18.6	889	7.61
picking up small coin	637	5.45	776	6.64
dressing including shoes and socks	767	6.57	804	6.88
preparing a hot meal	383	3.28	1424	12.19
shopping for groceries	629	5.39	1169	10.01
taking medication	277	2.37	825	7.06
managing money	240	2.05	848	7.26
<i>Cognitive Function</i>				
immediate verbal recall test score (0-8)	10441	5.67 (sd 1.38)	1239	10.61
delayed verbal recall score	10442	5.064 (sd 1.87)	1238	10.60
<i>figure copy test</i>			1917	16.41
zero intact figures	1,010	8.65		
one intact figures	1,659	14.2		
two intact figures	7,094	60.74		
<i>figure recall test</i>			2015	17.25
zero intact figures	4,787	40.98		
one intact figures	2,698	23.1		
two intact figures	2,180	18.66		
score of visual scanning test (0-60)	9785	25.06 (sd 15.07)	1895	16.22
<i>size of locality</i>			0	0
100,000 +~	6,800	58.22		
15,000 - 99,999	1,785	15.28		
2,500 - 14,999	1,094	9.37		
< 2,500	2,001	17.13		
died in period 2001-03	526	4.5	0	0
receives help with ADLs	281	2.41	0	0
receives help with IADLs	660	5.65	0	0

~ Reference category in the estimations

The Frailty Index²² presented in Chapter 4 was included in the analysis in order to have a comprehensive indicator of health status and wellbeing of our sample as an additional explanatory variable. A variable indicating quartiles of the index was also generated for the analyses.

The first step needed in order to generate the survival analysis was to set the data as required by Stata in order to define: the entry point for the analysis, the end-point, survival time, and the modalities of the outcome measure. The entry point of the study was defined as the date of first interview completed in the first wave of the MHAS in 2001. Variable *inter01* registers this date. For the end-point two separate dates were defined.

For those that were still alive in 2003 and were successfully contacted and interviewed, the interview date was defined as their end-point for analysis. For those that had died at some point in the follow-up period, the date of death was registered as reported by the next of kin successfully contacted and interviewed. This variable was defined as *inter03*.

As required by survival analysis, respondents that were alive and re-interviewed in 2003 are treated as censored observations. For the outcome measure, a variable indicating failure was defined and coded as 1 if the respondent died and 0 if the respondent is censored.

In setting the data for survival analysis, Stata generates an additional variable which defines survival time. This variable is defined by the count of number of days from first interview (2001 MHAS wave) to second interview (2003 MHAS wave) or date of death.

In addition, an alternative setup was tried by accounting for the number of months that elapsed between those dates. Obviously the results are the same, but having a smaller number of periods, i.e. months instead of days is sometimes preferred for graphical representation and exploration.

²² Following Rockwood, K., Mitnitski, A et al. the Frailty Index is generated by dividing the number of deficits or conditions an individual in the sample accumulates, by the total number of deficits. The total number of deficits for this study is 41. An extensive description of how the Frailty Index was generated is presented in Chapter 4.

6.5 Results

6.5.1 Non-parametric survival analysis: Kaplan-Meier Product-Limit Estimation

The Kaplan-Meier curves in Figures 6.1-6.6 show differences between men and women in terms of their survival and between those married or in a union and single individuals, where men and those with no partner having a lower probability of surviving at the end of the period under study.

It can be noted from the results, that the survival curves show no significant differences in the probability of surviving according to size of the locality of residence.

Regarding the age group of the individuals, there appears to be no significant difference between those aged 50-59 and those 60-69 regarding their probability of survival, while the probability of survival of the oldest group of 70 years and older decreases significantly compared to the group of 60-69 year olds.

Figure 6.1 Kaplan-Meier survival estimator for the overall sample

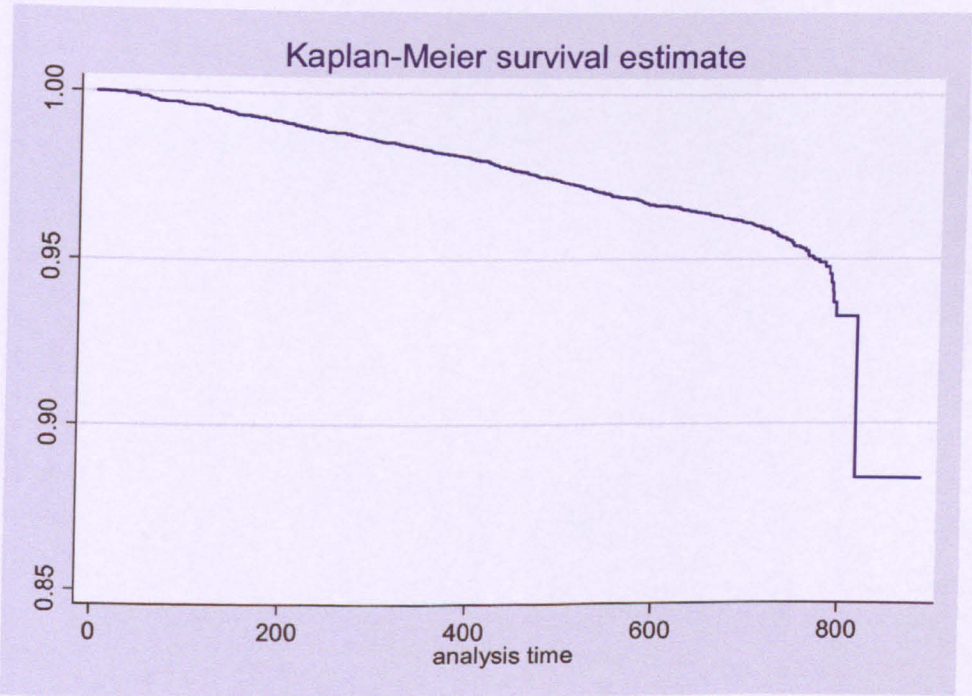


Figure 6.2 Kaplan-Meier survival estimator by sex

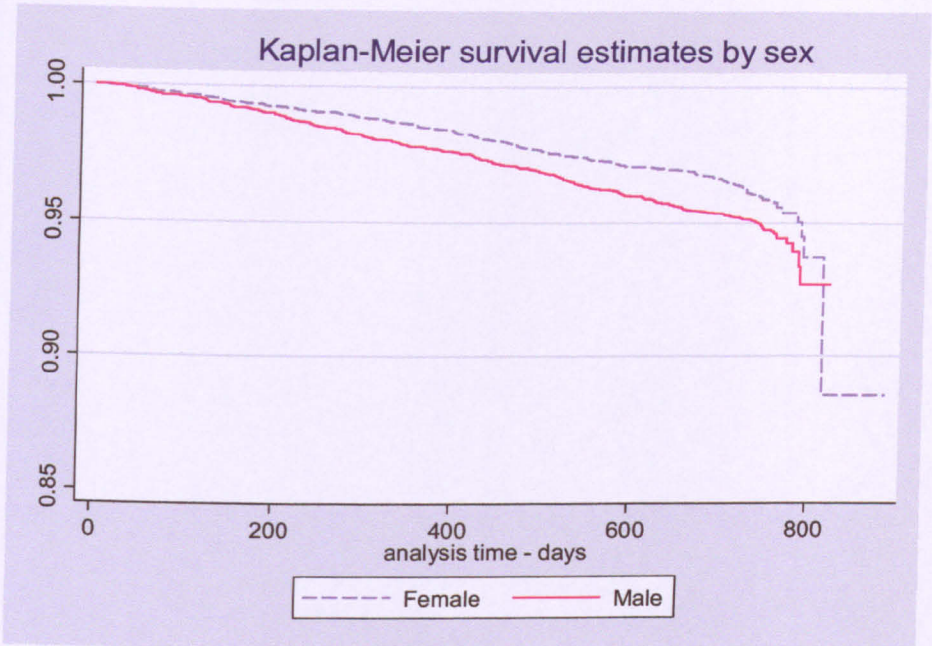


Figure 6.3 Kaplan-Meier survival estimator by marital status

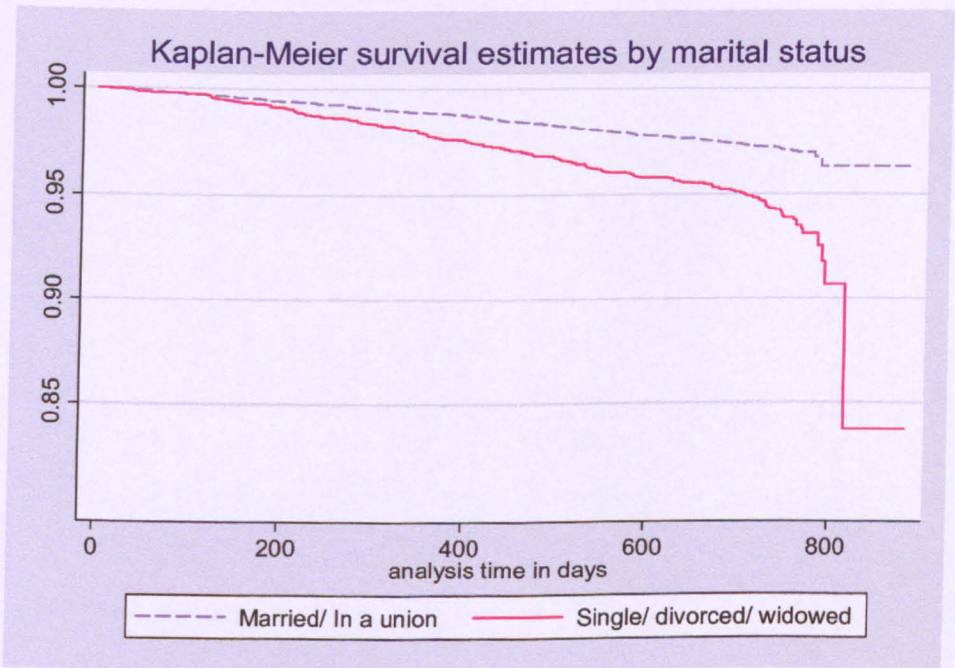


Figure 6.4 Kaplan-Meier survival estimator by age group

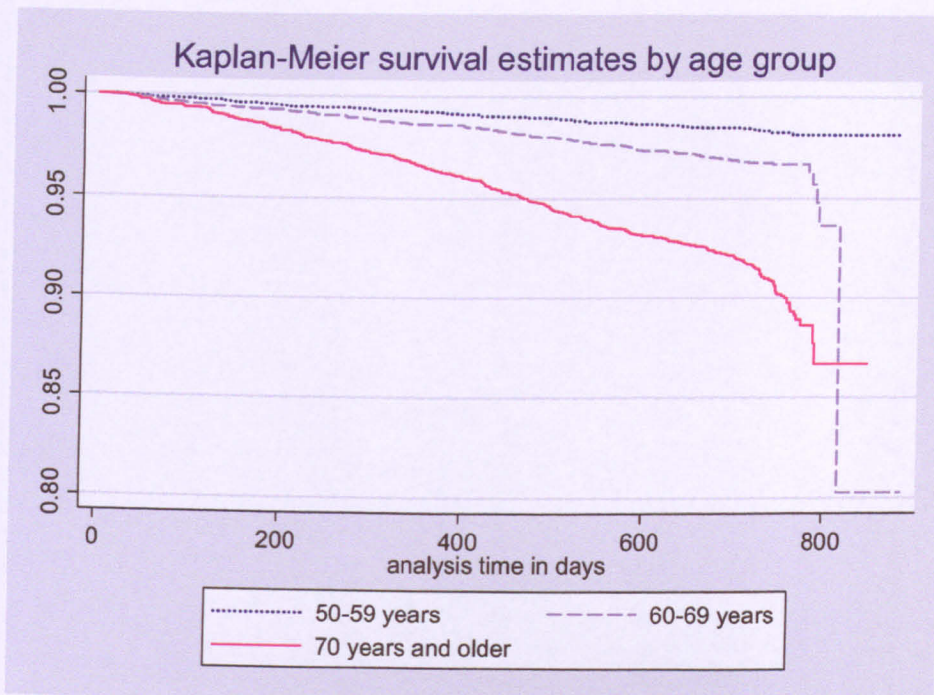


Figure 6.5 Kaplan-Meier survival estimator by size of locality

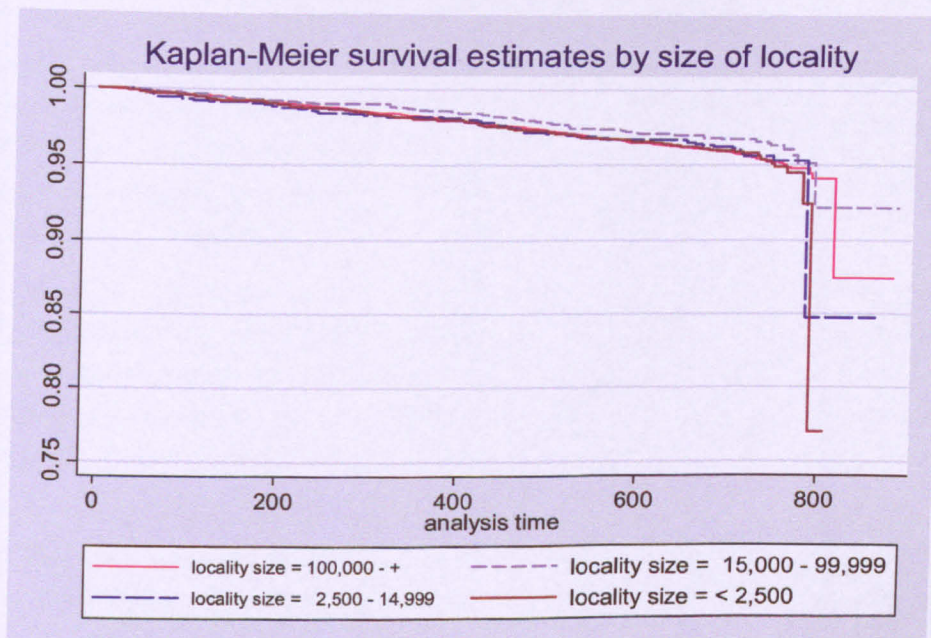
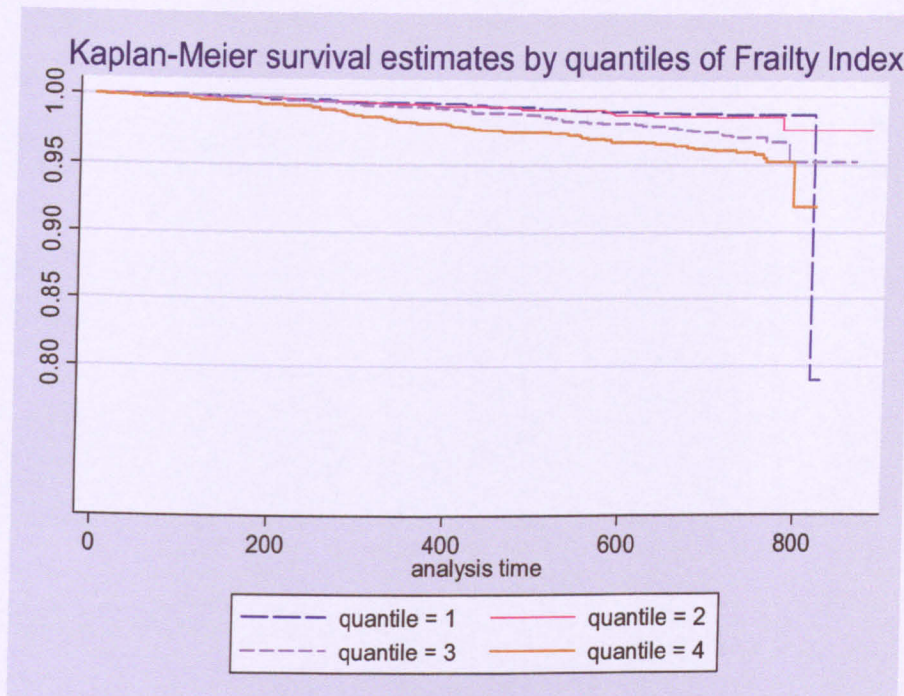


Figure 6.6 Kaplan-Meier survival by quartiles of Frailty Index



The Frailty Index was used to compare the probability of death or the hazard accumulated in the period of study (2001-2003) in this sample of the ageing Mexican population. Thus, the Kaplan-Meier survival and cumulative hazard Nelson-Aalen curves were also estimated using the Frailty Index as covariate. As shown in Figure 6.6, there is no significant difference between quartile 1 and 2 but survival appears lower for the third and fourth quartiles.

The hypothesis of no difference in survival among different groups was tested using the log-rank and the Peto-Peto-Prentice (Cleves et al 2004, 2008) tests. The results summarised in Table 6.2 show that there are statistically significant differences between being married or in a union and being single (including divorced and widowed), between the three age groups, and between males and females.

Thus, the hypothesis that the survivor functions of these groups are the same is rejected. This was not the case for size of locality for either of the two indicators used to measure this where there were no significant differences between the groups. Additionally, although using a much smaller sample there is a significant difference especially among the last quartiles of the frailty index.

Table 6.2 Tests for equality of survivor functions between groups (comparison)

Variable		Events observed	Events expected	Chi2	Pr> Chi2	Test*
Gender	Female	254	287.55	8.65	0.0033	LR
	Male	272	238.45	8.72	0.0031	PPP
Age	50-59	70	190.40	278.66	0.0000	LR
	60-69	138	186.09	277.50	0.0000	PPP
	≥ 70	318	149.51			
Residence	Rural	185	176.30	0.65	0.4202	LR
	Urban	341	349.70	0.66	0.4181	PPP
Marital Status	Married or in a union	219	289.72	56.05	0.0000	LR
	Single, Widowed or Divorced	200	129.28	55.71	0.0000	PPP
Frailty Index	1 Low	21	38.59	31.75	0.0000	LR
	2	23	37.40	31.79	0.0000	PPP
	3	45	37.99			
	4 High	62	37.01			
Community Size	< 2,500	92	86.60	3.28	0.3505	LR
	2,500-14,999	48	47.66	3.28	0.3498	PPP
	15,000-99,999	66	80.71			
	≥ 100,000	320	311.03			

*LR: Log-Rank PPP: Peto-Peto-Prentice

6.5.2 Semi-parametric survival analysis: Cox proportional hazards model

The results of the non-parametric analysis provide an initial estimate of the survival and cumulative hazards in a sample of the ageing population in Mexico and identify relevant covariates to be used in the third part of the survival analysis, the estimation of Cox proportional hazards regression models.

The estimated hazard ratios (HR) for the covariates in the univariate models are presented in Table 6.3 variables with $p\text{-value} \leq 0.01$ are defined to be significantly associated with mortality.

Table 6.3 Predictors of mortality: Univariate Cox proportional hazards estimations

Variable	Complete-Case analysis					Multiple Imputation analysis				
	Hazard Ratio	P>z	95% CI		Obs.	Hazard Ratio	P>z	95% CI		Obs.
Male	1.370	0.001	1.13	1.66	10958	1.292	0.003	1.09	1.53	
age group					11680					
60-69	2.018	0.000	1.51	2.69		2.879	0.000	2.18	3.80	
70+	5.795	0.000	4.47	7.51		8.868	0.000	6.89	11.41	
size of locality					11680					
15,000 - 99,999	0.795	0.089	0.61	1.04		0.795	0.090	0.61	1.04	
2,500 - 14,999	0.979	0.891	0.72	1.33		0.979	0.891	0.72	1.33	
< 2,500	1.033	0.786	0.82	1.30		1.033	0.787	0.82	1.30	
locality 100,000+ pop	0.929	0.420	0.78	1.11	11680	0.929	0.421	0.78	1.11	
single	2.049	0.000	1.69	2.48	10958	2.203	0.000	1.86	2.61	
Education					10952					
up to Primary	0.569	0.000	0.46	0.70		0.561	0.000	0.46	0.68	
at least Secondary	0.404	0.000	0.30	0.55		0.399	0.000	0.30	0.53	
speaks indigenous language	1.099	0.624	0.75	1.60	10838	1.027	0.898	0.67	1.57	
Frailty Index total					5848					11680
quartile2	1.131	0.684	0.63	2.04		1.911	0.006	1.21	3.01	
quartile3	2.177	0.003	1.30	3.65		3.005	0.000	2.00	4.52	
quartile4	3.082	0.000	1.88	5.06		5.684	0.000	4.01	8.05	
Frailty Index Male					2771					5333
quartile2	1.494	0.272	0.73	3.06		2.278	0.003	1.34	3.88	
quartile3	2.504	0.007	1.28	4.89		3.205	0.000	1.88	5.46	
quartile4	2.918	0.002	1.47	5.81		6.263	0.000	3.96	9.92	
Frailty Index Female					3077					6347
quartile2	0.401	0.171	0.11	1.48		1.361	0.461	0.58	3.20	
quartile3	1.721	0.198	0.75	3.93		2.945	0.000	1.66	5.23	
quartile4	3.524	0.001	1.70	7.32		6.038	0.000	3.64	10.03	

The results of estimating the Cox regression models for each variable separately show how being male, being in the oldest age groups, and being single (including divorced and widowed) impose a higher mortality hazard. Compared to those with no formal education, those with formal education seem to have a lower hazard, with this hazard decreasing as formal education increases.

A second model was estimated using the Frailty Index as a covariate in the analysis. Models were estimated for men and women separately and together. The results, presented in Table 5.3, suggest that for men being in the third or fourth quartile of the frailty index (higher frailty) increases the hazard of mortality (lowers the survival time), while for females this is true only for those in the fourth quartile, which would be those with very frail status.

Variables that were found to be statistically significant in the univariate analyses were next used in a multivariate Cox regression model to assess the independent contribution of each variable, controlling for the effects of the others (Table 6.4).

The results of the estimations for the model using the Frailty Index are initially presented separately given that they are based on a smaller sample.

Table 6.4 Predictors of mortality for the Multivariate Cox proportional hazards estimations

Variables	Complete-Case analysis					Multiple Imputation				
	Hazard Ratio	P>z	95% CI		Obs	Hazard Ratio	P>z	95% CI		Obs
male	1.641	0.000	1.34	2.01	10952	1.518	0.000	1.27	1.82	11680
age										
60-69	1.869	0.000	1.36	2.57		2.627	0.000	1.98	3.48	
70+	4.076	0.000	0.62	3.02		7.011	0.000	5.39	9.11	
single	1.825	0.000	0.19	1.48		1.718	0.000	1.43	2.07	
Education										
up to Primary	0.705	0.001	0.57	0.87		0.759	0.006	0.62	0.92	
at least Secondary	0.595	0.001	0.44	0.81		0.677	0.007	0.51	0.51	

The results of the model including all the significant covariates show that, after controlling for other variables, having a higher level of education results in a lower hazard and therefore a longer survivor time than those with no formal education. Regarding marital or partner status, being single (including divorced, separated, and widowed) has a higher hazard and shorter survivor time than individuals that are married or in a union.

As expected, as age increases the hazard increases (and survival time decreases). As was observed earlier, men face a statistically significant higher hazard than women, and shorter survival time.

The multivariate models were also fitted with robust variance estimators to try to account for within household characteristics. The results did not vary and thus they are not presented here.

Additionally, in order to test for any potential interactions within the covariates in the analysis, the Cox proportional hazards multivariate models were also estimated including the interactions between education and age; frailty level and age; frailty level and sex; and marital status and sex.

These models were tested against the original models by estimating likelihood-ratio tests of goodness of fit between the models, and the covariates with interaction terms were tested using the t-test.

Neither the coefficient of the interaction terms in the new estimations nor the improvement in the fit of the new models proved to be significant, which indicates that the original models are superior and that all the covariates are independently significant.

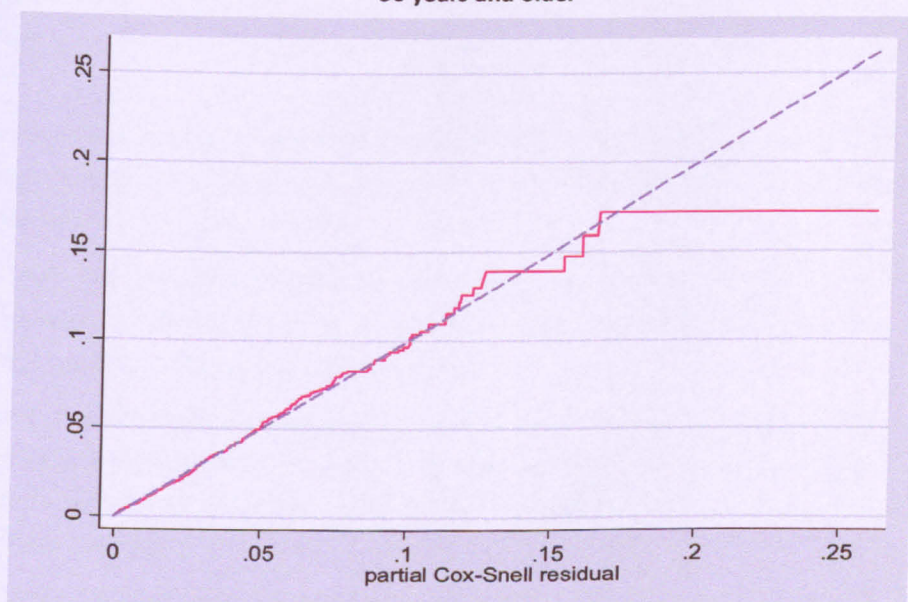
After fitting the final Cox proportional hazards model it is important to verify if it adjusts properly to the data and to check the proportional hazards assumption (Cleves et al., 2008; Marubini and Valsecchi, 1995).

One way to check or test for proportionality assumption is through the generation of plots of the proportional hazards²³. Another more robust method to check the proportionality assumption is based on analysis of the residuals of the model. In order to run Stata's test based on Shoenfeld residuals, the regression model was run separately with the required specifications.

Appendix 2-model 1 presents the global test and individual test for each covariate of the model as well as the proportional risks plot for each covariate in the model. The null hypothesis that the risks are proportional is verified in the curves as they are parallel from one another, and in the global result of the test ($p=0.1641$).

In order to test the overall model fit, Cox-Snell residuals were estimated and plotted against the cumulative hazards function (Figure 6.7).

Figure 6.7 Test of the overall fit of the proportional hazards model in a sample of Mexicans 50 years and older



²³ Of the different graphical methods for assessing the proportionality of hazards, a plot of the hazards and a plot of the Kaplan-Meier estimates are available in Stata (Cleves et al 2004, 2008)

The graph shows an almost straight line with a slope equal to one that goes through the origin which in general indicates a good fit of the model.

The final step in the analysis was to measure the effect of different health and disability characteristics of the sample population on mortality. This was done by including the Frailty Index in the model as an additional explanatory variable.

Table 6.5 Predictors of mortality Cox proportional hazards multivariate model including frailty status

	Complete-Case analysis					Multiple Imputation				
	Hazard Ratio	P>z	95%	CI	Obs	Hazard Ratio	P>z	95%	CI	Obs
male	1.870	0.000	1.32	2.65	5484	1.763	0.000	1.47	2.12	11680
age										
60-69	1.403	0.135	0.90	2.19		2.426	0.000	1.83	3.21	
70+	2.909	0.000	1.89	4.47		5.811	0.000	4.46	7.57	
single	1.587	0.010	1.12	2.26		1.683	0.000	1.40	2.03	
Education										
up to Primary	0.856	0.442	0.58	1.27		0.803	0.028	0.66	0.98	
at least Secondary	0.703	0.168	0.43	1.16		0.810	0.144	0.61	1.07	
Frailty Index total										
quartile2	1.050	0.872	0.58	1.90		1.680	0.025	1.07	2.63	
quartile3	1.969	0.011	1.17	3.31		2.424	0.000	1.60	3.66	
quartile4	2.710	0.000	1.64	4.49		3.998	0.000	2.81	5.68	

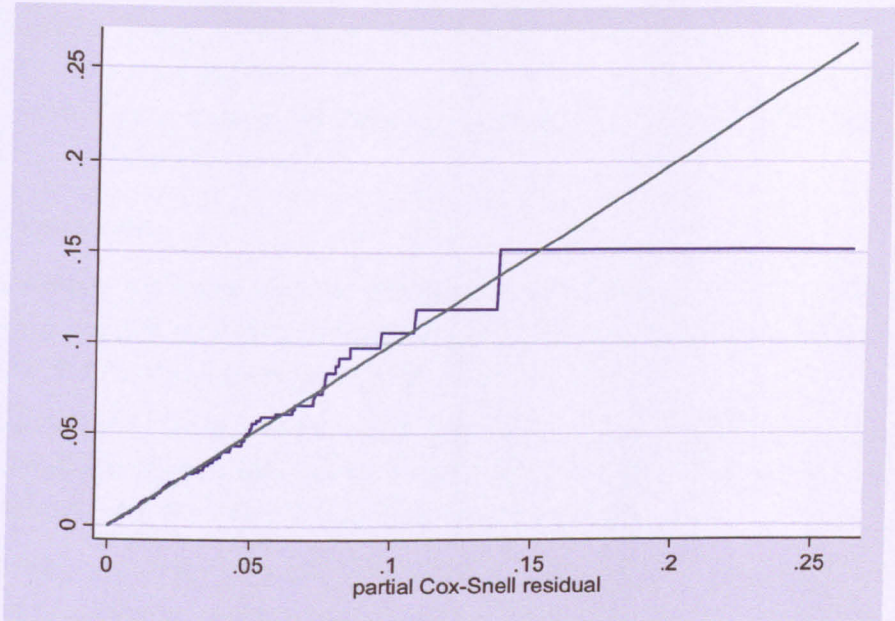
As Table 6.5 shows, by including the health and frailty indicator in the model, some socio-demographic indicators cease to be statistically significant in influencing mortality.

In particular, being in the 60-69 years old group, and the educational attainment covariates; while being male, in the oldest age group (70 years and older) and single continue to represent a higher risk.

Looking at the frailty covariates the results show that after controlling for the socio-demographic characteristics, being in the two highest quartiles of the frailty index is associated with an up to two times higher risk or decreased survival for individuals in these groups.

In order to check the proportionality assumption and the overall fit of the model, the relevant tests were carried out as described for the earlier model. Both tests show that the proportionality assumption is not violated (Figure 5.8 and Appendix 2-model 2).

Figure 6.8 Test of the overall fit of the proportional hazards model controlling for frailty status in a sample of Mexicans 50 years and older



In order to test the fit of the two models, with and without frailty as covariate, the first model that does not include the Frailty Index was estimated for the sub-sample of individuals who have a non-missing value in their Frailty Index score (5848 observations), and likelihood-ratio tests for this model and the second model including Frailty were performed. The results are significant indicating a good fit by including frailty in the estimations [$Prob > \chi^2 = 0.000$]

In sum it can be seen that that the results are similar for complete case (CC) and multiple imputation (MI) data sets. This consistency was expected given that in general the extent of missing data was low for most variables. Consistent CC and MI results were observed for most of the Hazard Ratios with similar values in the complete case and imputed models, with the exception of age where all the hazard ratios for the MI models are higher than for the complete-case models.

The MI models seem to differ more markedly from the complete case-case models, in those analyses that include the frailty index. When using the MI data set, the results of the univariate and multivariate proportional hazards model regressions have a much higher significance (smaller p values), than those in the complete-case models.

Additionally, the Hazard Ratios of the MI models suggest that the effect of being frail or of higher frailty status is much larger when all the observations are included in the model. Thus, we can again observe how frailty increases the hazard of mortality (lowers the survival time) for both men and women, although consistent with complete-case models, the effects, or risk of mortality continue to be much higher for men than for women.

6.6 Discussion

In this chapter a survival analysis was carried out in order to study the effect of different covariates on overall mortality using data from a nationally representative sample of the Mexican population aged 50 years and older.

The study gives an initial relevant insight into the survival process of this population group. The main findings show important differences among some groups regarding their survival using the Kaplan-Meier product limit estimator.

Additionally, using the Cox proportional hazards model allowed an analysis of how different covariates or characteristics of this population group increase or decrease their hazard of mortality.

The main findings of this study show that survival or the complementary mortality hazard is significantly determined by the following factors. First, the results clearly show a significant difference in the survival of men and women. Whereas in general women accumulate more deficits than men, shown in individual indicators such as number of chronic diseases, symptoms of depression, etc., as well as through the score of the Frailty Index; men have a significant higher risk of dying than women. This can be clearly seen both by exploring their survival curves and through the univariate and multivariate Cox proportional hazards model estimations.

The fact that while women accumulate more deficits, men have higher mortality has been noted in earlier studies for other countries (Puts, Lips, and Deeg, 2005; Idler and Kasl, 1995; Kuzuya et al., 2006; Ho, 2008), and is highly significant for future planning of health care strategies and programmes for the ageing population.

Second, similar to results of studies from other countries (Andrew, Mitnitski, and Rockwood, 2008; Ho, 2008) it was very interesting to find in this study, that those without spouse or partner (including those separated, divorced, or widowed) present a higher risk of mortality.

As expected, increasing age, particularly after 60 years, imposes a higher risk and thus individuals increasingly have a lower probability of survival.

Finally, when the Frailty Index was introduced into the analysis, the results show an increasing risk of mortality as frailty status increases. This follows results from the original studies using the Frailty Index (Rockwood et al., 1999).

The results also show how once this comprehensive health and disability indicator is included, its impact on survival appears to be much higher than socio-demographic characteristics which to some extent cease to be significant. The Frailty Index seems to be a strong and significant predictor of mortality and a useful analytical tool.

Given that other studies have also indicated that the number of deficits accumulated is a stronger predictor of mortality than which markers or deficits an individual has, the results of this study where those in the highest quartile score of the index show highest risk of mortality should be considered in future planning of services.

Thus, it seems relevant to concentrate on preventive strategies and strong support to achieve good follow-up and adherence to treatment in order to prevent the accumulation of deficits or to slow down the degenerative process of the ones already accumulated.

Most of the vast literature using survival analysis concentrates mainly on specific conditions and thus is beyond the scope of this study. However, the studies reviewed helped to understand the process of the analysis and how it differs or not depending on the specific condition under study.

Within the smaller sample of literature regarding survival analysis of the older population, to my knowledge, this is the first work to analyse survival using a nationally representative sample of the Mexican population 50 years and older, and additionally to explain some of the characteristics and determinants of the differences in risk of mortality within this population group. This is one of the main strengths of this study.

In contrast to much of the related literature that only uses physical and/or biomedical domains to analyse survival; this study adds to a much smaller literature that includes different socio-demographic and social support indicators as covariates in the analysis.

Additionally, compared to most studies of health and frailty which work only with complete-cases, by generating a multiple imputation procedure and using the multiple imputed data set to compare results and possibly reduce the likelihood of bias or incorrect results, this study adds to the still scarce literature on applied multiple imputation in these related topics.

Given that the Cox proportional hazards model works better with few covariates, using the Frailty Index to analyse survival in the ageing population offers a big advantage over other studies regarding the added information and for the robustness of the present work.

In sum, this study demonstrates how the risk of mortality is significantly higher for men, those without a spouse or partner, and for those 60 years and older. In addition, those that have accumulated a higher number of deficits have the lowest probability of survival independently of other socio-demographic and social support factors. These findings are consistent with those of previous studies.

Still, there are some limitations to this study. First, as opposed to a large number of survival analysis studies, at the moment the Mexican Health and Ageing Study, MHAS only observes respondents over two years. It is to be hoped that the study will continue in coming years in order to allow for a longitudinal long-term frailty and survival analysis of the ageing population in Mexico.

Second, while multiple imputation procedures seem a valuable tool for obtaining more robust estimations, the limited range of post-estimation tests available with the mim procedure poses some restrictions on the analysis and greater reliance than is desirable on complete-case analysis. Hopefully, the constant advances in such procedures will soon allow for such estimations.

Finally, there are relevant recommendations for future work. First, given that this study was limited to static /cross-sectional analysis of frailty and survival in one period, it is desirable to also generate a dynamic analysis of frailty to analyse changes of state from one wave to the next and the Frailty Index is a sound instrument with which to do so.

Additionally, given the results, and the importance that care and social support seems to play in overall frailty and survival of this sample population, it would be interesting to study more extensively issues such as living arrangements, as well as other measures of social support and participation.

Chapter 7 Predictors of health care utilisation among a sample of the Mexican population 50 years and older

7.1 Introduction

In the past decades, as population ageing becomes a reality in many countries, health care services use by the elderly population and the related costs forgone to cover such care have become a major topic of interest and the purpose of increasing empirical work. Although a very large part of the ageing population may be healthy, it is very likely that they will suffer from one or more illness. Consequently, the impact of this on preventive and curative services and their financing could be significant, especially regarding the oldest old.

It is frequently said that the increasing absolute number of older population groups will inevitably increase total health care use and expenditures. However, findings are not conclusive, with some early studies finding that health expenditures per person not only increase in age, but also that the rates of increase in per capita health spending are greatest for the older groups (Mahal and Berman, 2001). On the other hand studies show how population ageing is only one in a combination of factors that have increased total health expenditures such as increasing complexity of technology and its use, organisation and functioning of health care institutions, among others (Jacobzone and Oxley, 2002; Rechel et al., 2009; Mayhew, 2000).

As observed in other studies (Wolinsky, Mosley, and Coe, 1986) utilisation of health services does not necessarily resemble a perfect U shape where infants and the oldest-old individuals have the highest utilisation rates. Data from the National Health and Nutrition Survey 2006, ENSANUT shows that utilisation of health services shows more a combination of part of a U shape in the first years of life, and an inverse J shape for adults (Olaiz G et al., 2003).

After ages 0-4 years utilisation of curative and preventive services decreases significantly until age 20 when it starts to increase gradually reaching a peak approximately at 60-69 years and slightly decreasing from then on for the oldest old, especially at ages 80 years and older. On the other hand, utilisation of inpatient hospital services does not show a clear trend or shape with high-points at different ages: 0-4, 20-29, and increasing at older ages.

In previous chapters, results showed that although women in general have higher morbidity and disability, especially as observed in the Frailty Index score, they live longer than men. This higher accumulation of health conditions and higher frailty in

women could be expected to translate to higher use of health care services. However greater utilisation by women has not been a general finding in the literature and usually depends on the type of service used.

Results from the ENSANUT 2006 are in accordance with these statements. Although women show more contact with physicians and medical doctors and use more preventive services, men show a higher use of hospitalisation and emergency services, such as treatment of accidents and violent events.

Given the lack of integrated or comprehensive long-term health and social care programmes in Mexico, there is uncertainty regarding the utilisation of health care services by the ageing and oldest population groups.

As in many developing countries, in spite of increasing numbers expenditures directed at the older population in Mexico have been scarce compared to efforts and related expenditures in areas such as infant and maternal mortality, as well as programmes directed to newborn, children, and working age population groups which may just reflect pressing needs of past decades (Borges-Yañez and Gómez-Dantés, 1998).

The role of social support and networks is also very important in terms of overall wellbeing of the older population. In the vast literature on informal care, it has been observed how the majority of care of older individuals worldwide is done in the household by family and other close relatives or friends. This is true even in countries with multiple opportunities for publicly funded long-term care support for older individuals in need.

In Mexico, the lack of comprehensive strategies to cater for the older population, and recent efforts to reduce length of stay and cut costs in the health system, have basically left families in charge of the older members of their family with little support from institutions. Given that social support has been noted as an important determinant of use of medical services, especially in the case of the oldest population, the role of social support and network needs to be taken into account in studying utilisation of health services by this population group in Mexico.

While in terms of their needs older population groups may imply higher demands and higher expenditures, the lack of long-term care programmes and the few new palliative programmes that cater for older individuals seems unlikely to lead to as sharp an increase in total expenditures as has been foreseen.

In this context, it is of high relevance to investigate and understand the underlying process of health care utilisation by older individuals in Mexico, given the current structure of services. This will be of value because of an imminent need to plan and restructure different services in order for them to appropriately cater for the changing needs of an ageing population.

The aim of this chapter is to investigate the determinants of the need for health care services by a sample of the Mexican population 50 years and older. Given the important socioeconomic and demographic differences in the country, the analysis of utilisation of health services will try to incorporate an equity perspective and investigate if inequities prevail in relation to access to health services and their use. In order to do so, factors such as insurance status, individual income, size of locality of residence, will be analysed, as well as utilisation by different age and education sub-groups.

Gender inequity in health status, financial barriers, and access to health services in Latin America has been widely documented (Gómez Gómez, 2001, 2002). Within the older population groups in Mexico, especially within the oldest-old group, women grew up in contexts of high gender inequity regarding their expected role as homemakers, and with little opportunities to do otherwise; to get an education, to participate in the labour force, or any other sphere outside the household. In this context, older women in Mexico may face additional disadvantages in access to health and social services. Thus, it is desirable to investigate beyond the clear sex differences in health and mortality, if and how such differences prevail regarding their access and utilisation of health services.

The chapter has the following sections. Some of the main conceptual frameworks of health services utilisation are reviewed followed by a section on previous empirical work on this topic. The methods to be used in the modelling of health services utilisation by older population groups in Mexico, including the statistical analysis carried out are presented in section three. The data and sample used for the analysis are presented in section four followed by the results in section five. The final section presents a discussion including strengths and limitations of the study as well as recommendations for future work.

7.2 Conceptual framework

Conceptual or theoretical frameworks that guide the study of the demand for health care services have identified different aspects that determine such utilisation. Under an economic perspective, analysis is centred on market characteristics of health

services by identifying those factors that encourage or impede the consumption of such services, while additionally identifying and possibly modifying the barriers to such access (Arredondo López, 2002).

Becker's discussion of the importance of total time not spent in work, the way individuals allocate their time to non-work and otherwise productive activities, and the decisions they make around it, led him to generate his theory of allocation of time (Becker, 1965). At the heart of the theory is the view that households are producers as well as consumers, and each household is seen as seeking to maximize the utility of its members under two main constraints, financial resources and the amount of time available for work and non-working activities. At the individual level, the notion is that individuals invest in themselves by increasing their knowledge.

This increases their productivity in the market sector which brings increased earnings and within the household sector, the individual produces "commodities" that enter their utility function. More precisely in his words "Households will be assumed to combine time and market goods to produce more basic commodities that directly enter their utility functions. ... They combine time and market goods via "production functions" f_i to produce the basic commodities Z_i and they choose the best combination of these commodities in the conventional way by maximising a utility function".

Building on Becker's work, Michael Grossman (1972) generated a human capital model of the demand for the commodity "good health". The main proposition of the model is that consumers do not demand health services per se but rather good health. It is assumed that individuals inherit an initial stock of health that depreciates with age and can be increased by investment. In Grossman's model (1972, 1999), health capital differs from other forms of human capital.

In particular, a person's stock of knowledge affects their market and non-market productivity, while their stock of health determines the total amount of time they can spend earning income and producing commodities. Grossman extended his work by generating a wide number of empirical studies in the areas of health and education.

An additional theoretical framework for the utilisation of health services was generated by Andersen (1968) and has since become one of the most widely used. In his behavioural model of families' health services utilisation he explains families' use of health services based on a three-stage model suggesting that a sequence of

conditions contribute to the volume of health services used. Use of services is dependent sequentially on the predisposition of the family to use services; the families' ability or access to secure services; and finally, their need for such services, and the importance of each component depends on the judgment exercised by families in using services (p. 14).

Within predisposing characteristics Anderson includes the families' composition, their social stratus, and their health beliefs. Regarding enabling factors, these are defined by family resources and community resources that facilitate or impede individuals' decisions to seek care. Finally the need sub-component includes illnesses and the response to such events.

In later work Andersen (1995) shifted the focus of his model from the family to the individual as the unit of the analysis. Additionally, Andersen and Newman (1973, 2005) define three categories of determinants of health service utilisation: the initially defined individual determinants, that is, predisposing, enabling, and need factors; health system characteristics including the organisation and functioning of the available health services; and societal determinants, including technology and norms. Thus, later models include individual health behaviour with respect to personal health practices and use of health service with the final outcomes being perceived health status, evaluated health status and consumer satisfaction.

Although the original model and its modifications were created for the United States, and therefore probably not perfect for use in other settings, it is the model that has been most widely used in estimating use of health services by older population groups, using a wide range of samples, in different countries, and for different types of services. This model offers the advantage of a clear classification of the main factors that may explain or determine health service utilisation in three subgroups, making it easy to organise the data and the analysis accordingly.

However, these models were designed to study formal care services and do not place a much needed emphasis on family care and the role it has in overall utilisation of services and health of the service users. In addition, they do not include among enabling characteristics factors, such as empowerment, which can be an important determinant in the use of health services.

Although there appear to be many studies investigating how women's empowerment, especially in rural or very poor settings, increases their use of reproductive health and maternal health services, and some studies were identified

on empowerment and the use of mental health services, research in other areas seems to be scant and should be considered in the future.

Despite the scope for including additional factors, adopting the Andersen model as a conceptual framework for the Mexican study is desirable, even though studies using Andersen's model are not closely comparable due to differences in terms of ad hoc modifications of the model, and large differences in the samples and estimation methods used. This will allow identification of individual determinants of use of services, as well as observation of any similarities with other studies regarding which factors are significant in determining service use.

Accordingly, the variables under study were selected following the enabling, predisposing, and need factors defined by the model, and included additional factors considered relevant to the Mexican study such as helped received in order to perform daily activities. The variables included in the study are described in detail in section four.

7.3 *Previous empirical work*

7.3.1 General

Since these conceptual frameworks were developed, there has been an immense number of empirical studies on the demand and utilisation of different types of health services (e.g. medical doctor visits, nights spent in hospital, dentist visits, accident and emergency services), or for specific needs (e.g. use of services by cancer patients). However, a much smaller sample of studies has focused on non-demanders or non-users that is, those who even when there is access or need do not use a particular service. Also, it is only in recent decades that empirical studies have focused on the demand for and utilisation of health services by the older population groups. This has happened as issues surrounding long-term care and services for this group of the population have become more pressing.

Regarding utilisation by older population groups, it seems that for decades empirical work was concentrated in studies in the United States (Wan and Odell, 1981; Wolinsky, Mosley, and Coe, 1986; Soldo and Manton, 1985; Evashwick et al., 1984) and Canada (Strain, 1990; Chappell and Blandford, 1987). More recent work has been undertaken in European countries such as the UK (Bowling, Farquhar, and Browne, 1991), the Netherlands (Portrait, Lindeboom, and Deeg, 2000; Knol, Haken, and Kempen, 2003), Sweden (Modin and Furhoff, 2004), and more recently, Spain (Fernández-Mayoralas, Rodríguez, and Rojo, 2000; Fernández-Olano et al.,

2006; Redondo-Sendino et al., 2006). Work on the use of health services by older population groups or including these age groups in a broader analysis from other regions, includes work for Australia (Cameron et al., 1988; Korten et al., 1998), and China (Foreman et al., 1998).

While these studies have the older population as their main focus, they have concentrated on a wide range of services, such as physician or general practitioner visits, social services including home care, nurse visits, etc., hospitalisation and nights spent in hospital or a combination of several types of services and examining the main determinants of older individuals seeking care and the times or frequency they seek such care.

From review of these studies, it is noted that Andersen's model has been most widely used whereas there is a wide range of approaches used with respect to methods. Summarising some of the methods used we have: a) two-stage models using logistic regression to model the probability of use in the first stage and OLS (Foreman, et al., 1998) or Multiple Classification Analysis (Wan and Odell, 1981) to estimate the amount of care; b) discriminant analysis to determine different characteristics among individuals in order to classify them into different groups of users and non-users (Fernández-Mayoralas, Rodríguez, and Rojo, 2000); c) bivariate and multivariate logistic regression (Chappell and Blandford, 1987; Bowling, Farquhar, and Browne, 1991; Modin and Furhoff 2002; Fernández-Olano, et al., 2006; Redondo-Sedino, et al 2006); d) hierarchical logistic regression to examine each of the sub-components of the Andersen model's framework separately and jointly (Evashwick et al., 1984; Strain, 1990; Knol, Haken, and Kempen, 2003); and e) count data models (Korten et al 1998).

Most studies were cross-sectional with few exceptions that generated, in addition, longitudinal analysis. Wolinsky, Mosley, and Coe (1986), for example, use data from the US to generate intra-cohort analysis by means of constructing cohort tables with data for three consecutive waves of the US National Health Survey. On the other hand, Knol, Haken, and Kempen (2003) explore differences in use of home care for different waves using a sub-sample of the Groningen Longitudinal Aging Study. In addition, most studies have used small sub-samples of a larger survey or samples from a city or region within a country.

As varied as these studies are regarding the sample used, methods, etc. it was interesting to find that need factors were the most relevant predictors of care and one of the groups or sub-components of the Andersen framework that explained

more variability in the use of services. For example, Wan and Odell (1981) found that need for services supported by physical and psychosocial functioning was the most important predictor of use of physician services and hospital stays.

Also for a sample in the US, Evashwick et al. (1984) found that need variables expressed in those with poor health status, predicted the highest utilisation of services such as physician visits and hospital care, while Chappell and Blandford's (1987) results for Canada show that need, and mainly functional ability were the strongest predictors of home care services. Results of the Chinese study (Foreman et al., 1998) found that need was the strongest predictor of the probability of spending a larger number of nights in hospital.

Other studies showed similar results where one or a group of need factors predicted either higher probability of using different types of services or higher frequency of use (Bowling, Farquhar, and Browne, 1991; Strain 1990; Fernández-Mayoralas, Rodríguez, and Rojo, 2000; Fernández-Olano et al 2006). In their study, Korten et al. (1998) found that measures of need, specifically disability and anxiety in women, and current self-reported health in men, were the most important predictors of contact with and extent of use of general practitioner services.

Additional predisposing and enabling factors, although with less significance, that came up in several studies as factors that influence use of services were, for example, that utilisation of health services is higher among women (Bowling, Farquhar, and Browne, 1991; Fernández-Mayoralas, Rodríguez, and Rojo, 2000), and in general for all health and social services with exception of hospitalisation which was higher for men (Evashwick et al 1984).

Interestingly, several studies show how individuals without a partner or spouse (including being divorced or widowed in some samples), or who live alone have higher probability and intensity of use of services (Wan and Odell 1981; Bowling, Farquhar, and Browne, 1991; Modin and Furhoff, 2004).

Contrary to what most studies expected, higher use of health services with increasing age was only found in a few of them (Evashwick, et al 1984; Bowling, Farquhar, and Browne, 1991; Foreman et al. 1998). Finally, knowledge of services, as an enabling factor, was found to be another strong indicator of use of social services (Wan and Odell 1981).

Having lower educational attainment was associated with higher use of services in Wan and Odell (1981); with higher number of visits to a medical doctor/physician/general practitioner (Fernández-Mayoralas, Rodríguez, and Rojo,

2000; Fernández-Olano, et al., 2006; Evashwick et al., 1984). In addition, the work of Korten, et al (1998) found that women with lower educational attainment were associated with higher number of general practitioner contacts.

On the other hand, for the study in China, Foreman et al. (1998) found that higher education or college level education had a positive and significant relation with the use of western-style physician services and with the probability of hospitalisation, but those with more education were less likely to use Chinese-style or traditional health professionals. Also, as opposed to a large number of the other studies, they found that women are less likely to visit a western-style physician than men, which according to the authors reflects the lack of status Chinese women have in local cultural values (p. 1276). These findings present larger support for the need to look for any possible inequities in the use of health services in the case of the older Mexican population.

7.3.2 Mexico

For a very long time, utilisation of health services in Mexico was only reported through basic official statistics, for example, on nights spent in hospital or number of beds used in a certain period of time. A major step forward came in the 1990s when the National Health Survey II (ENSA-II) was carried out in 1994 and the related data sets were made available shortly afterwards. This allowed for more comprehensive analysis not only of health status of the Mexican population, but also on use of services and its health, demographic, and socioeconomic determinants. Given that research on utilisation of health services by the older population groups in Mexico is scarce, some of the first and more influential documents on use of services by the general population were also included in this review of empirical work.

The first studies of use of services by the general population are those by Gómez de León et al. (1995) and Zamudio (1997). Gómez de León et al. (1995) develop a multinomial nested logit model which seeks to define the probability of selection of different health services, and the attributes of the available alternatives, but gives less attention to the attributes of the individuals. Their results indicate wide inequality in the distribution of health resources when studying travel time as part of the demand; also individuals covered by social security insurance prefer to incur costs/spend on services in order to receive private health services.

Zamudio (1997) estimates the probability of selection of a particular service taking into consideration the attributes of the alternatives to the services using a nested logit model. His results show that the main determinants of the demand for health services are health state, age, sex, income, and factors reflecting competing resources within the household, such as number of older persons. Additionally, place of residence regarding region of the country and size of locality are shown to be further determinants of demand.

Using more recent data, Arreola, Soto, and Garduño (2003) use the National Health Survey 2000, ENSA-2000 to explore the determinants of the non-demand for health services given a health problem or need is present, as well as describing the demand for services in the country. Based on Grossman's Utility Maximisation model they estimate a conditional multinomial nested logit on the probability of demanding, or not, both curative and preventive health services. The model is conditional on the probability of having been ill in the two weeks previous to the survey, limiting the possible choices in the second level of the model (first level being ill or not).

Their results show that the probability of being ill, suffering an accident or injury (two weeks previous to the survey) was 11.5% and within this group the probability of non-demand for curative services was 45%. If need is perceived as an individual process, that is the person suffered some type of illness, accident, or injury in the two weeks previous to the survey, non-demand is shown to be affected by the age –especially for the age 15-29 group. Additionally, barriers to access such as the costs of services, the distance to health clinic, not having enough money, not perceiving demand as a need, and not trusting the services were also identified as main determinants of non-demand.

Using individual-level data from the 2000 Mexican Survey of Satisfaction with Health Services Brown, Pagan, and Rodríguez-Oreggia (2005) study the decision-making process of health care utilisation using a two-part negative binomial hurdle model. The two equations estimate the decision to visit a physician or hospital using a probit model, and the number of visits or days spent in hospital using a truncated-at-zero negative binomial model. Their results show relevant differences by income in utilisation of doctor or physician services for the first visit. Additionally they find differences by region; employment and insurance status; as well as the potential user having financial difficulties. Regarding in-patient hospital services they did not find income-related differences but there were differences by

educational attainment and when having financial difficulties derived from health shocks or difficulties.

Finally, Valencia-Mendoza and Bertozzi (2008) estimate the demand for ambulatory services given some alteration in the health status of individuals. Their work uses a multinomial nested logit model which allows the estimation of the effect of the individual's alternatives by taking into account the type of health problem and its severity. "This allows controlling for the heterogeneity of the health problems and obtaining less biased estimates". Also, in order to control for possible differences at community level, it incorporates an Index of Poverty Level²⁴ generated by the Mexican Population Council, CONAPO.

Their results show that the probability of using services increases as age increases when health problems are present, and that considering all age groups women have higher probability of using services, which is as expected given their high use at reproductive age stages. Additionally, being employed has a negative impact on all ambulatory services use by women. Using per capita spending in a three month period as proxy of SES, results show that with the exception of the last two deciles of expenditures as spending increases percentage of use of services increases. Being insured has a positive and significant effect on the probability of utilisation of ambulatory services and a negative relation with use of private services and of MoH services although it was not significant for this last organisation. Education showed a positive and significant impact on utilisation, especially of private services. Finally, as expected severity of health problems, has a positive and significant effect on the probability of utilisation.

7.3.3 Older population groups in Mexico

In an early study of health service utilisation by the population 60 years and older Borges-Yañez and Gómez-Dantés (1998) used descriptive statistics and logistic regression to estimate socio-demographic characteristics and determinants of health services utilization using data from the ENSA-II survey. The prevalence of chronic diseases in this population group was also analysed.

The services most frequently used according to their results were private sector physicians; social security institutions' services (mainly IMSS and ISSSTE), and public services from the Ministry of Health. Interestingly, 25 to 45% of social

²⁴ Further information on the Index and its construction can be found in:
http://www.conapo.gob.mx/index.php?option=com_content&view=article&id=78&Itemid=194

security insurance holders in their sample study did not use their entitled services and stated they instead consult private sector physicians.

Using data from the same survey (ENSA-II 1994) (Durán-Arenas et al., 1996) estimated the direct financial requirements for providing health care to the elderly in Mexico and the actual expenditure on services. In addition, service use trends for the aged were obtained from health sector statistical yearbooks. Their results showed that in 1994 the health care needs of the aged already exceeded the amount of resources and the capacity of the health care sector to meet their needs. According to their estimates, 4.9% of the total public sector (Ministry of Health) was spent on hospital services for the elderly, while 5.6% was spent on general and specialist consultations for population 60 years and older. Although these percentages may not seem high, we have to consider they only account for publicly funded services, and expect them to have been steadily increased by different factors, of which the increase in the elderly population is the most remarkable since these calculations were made.

In a study in three major hospitals in Mexico City, (Borges-Yáñez et al., 1996) investigate the use of health services by the older population groups. Although there were differences between the three institutions, mainly due to the different scope of the services provided, in comparing the main causes of hospital stays with the twenty highest causes of morbidity within the population 65 years and older, chronic illnesses occupied the first places as cause of hospital stays/hospitalisation. Some of the main causes besides respiratory tract infections, diabetes mellitus, and hypertension included diarrhoea and amoebas. This indicates that although not a common cause of death any more, infectious diseases are still largely present in this population group in addition to chronic diseases.

Two studies covering small samples were identified in the literature, one for the city of Tampico in northern Mexico (Peñarrieta de Córdoba et al., 2006) and one using a sample of the older population within the vicinity of a Health Centre in the municipality of Netzahualcóyotl in the State of Mexico (Pacheco-Ríos et al., 2001). Both studies are cross-sectional and use descriptive statistics, while Peñarrieta de Córdoba et al. (2006) in addition use logistic regression to identify the factors that enable or restrict the use of health centres be they public (MoH), private, or social security services.

The results of the study in Tampico show that factors that enable use of public community health centres were not having medical insurance, not having a regular income or salary, living alone, and living in a household lacking basic services. On the other hand, for the study in Netzahualcóyotl, results show that 43% of the sample access services at the Mexican Social Security Institute, IMSS; 13% at the Institute for Social Security and other services, while 17% used public services provided by the Ministry of Health.

As it has been mentioned before, until the recent generation of the Mexican Health and Ageing Survey MHAS there was no nationally representative data source of the ageing population in Mexico. Only three studies were found on utilisation of services using this data set.

Using the components of the Andersen model and logistic regression analysis, (Pagán and Puig, 2005) explore how health insurance status influences visiting a medical doctor, a homeopath or traditional folk healer, and self-medication. Additionally, they estimate negative binomial regressions to study whether health insurance was associated with the number of visits to either type of services. Logistic regression results show that being insured is positively and significantly related to physician visits and negatively related to use of a folk healer or homeopath. On the other hand, the negative binomial regressions show that health insurance is positively associated with number of physician visits.

Further work using the MHAS survey includes logistic regression analysis to explore how health insurance status relates to the use of three general preventive services, hypertension, cholesterol, and diabetes; two services for women, Pap test and mammogram, and one specific for men, prostate cancer screening. Results show that uninsured adults were less likely to use preventive screening for hypertension, high cholesterol, diabetes screening, and all cancer screenings than insured adults. Similar results were observed for mammography and Pap smear tests for women aged 50-69 and for prostate cancer screening for men 50-69 years old. Thus, the uninsured faced significantly lower access to some preventive services (Pagán, Puig, and Soldo, 2007; Wong and Díaz, 2007)

Finally, a study by Wong and Díaz (2007) explores the determinants of health care utilisation of three main services: preventive care, medical doctor visits, and nights spent in hospital using multivariate probit regression methods including marginal effects and propensity to use these services by the older population in Mexico using the MHAS. In line with other studies, their results show how those in need,

reflected by individuals with fair or poor self reported health, are more likely to use all three types of health care services than those reporting excellent or very good status. Those reporting difficulties with at least one ADL/IADL tend to have higher medical doctor visits or hospitalisations, but there was no effect on preventive services.

Additionally, having one or more chronic illnesses increases the likelihood of using all services although the effect varies by illnesses. Also in line with the literature, women were more likely than men to use preventive care and have doctor visits but not to use hospital services where men were more likely. Education and income showed a positive relation with use of services with those in the highest education level and in the highest income group showing higher likelihood of using preventive services and medical visits. Finally, urban residents were more likely to use preventive care than those living in rural areas, but there was no differential use of doctor visits and hospitalisations within these groups.

More than ten years after the first studies on use of health services by the older population groups in Mexico, and their conclusions regarding the need for making the health of the ageing population a priority, there are still no comprehensive social and health care strategies or programmes for the elderly, but a research agenda has been increasingly developed and will it is hoped support the adequate planning and allocation of funds and services for the elderly in Mexico.

7.4 Methods

As was noted in the review of previous studies a wide variety of methods have been used in the empirical work on the utilisation of health services such as descriptive statistics, logit or probit models of the probability of using services, and a few applied choice analyses using multinomial logit and nested logit models. Still, many of these studies find low explanatory power of their models and conclude some other alternative methods could be tried.

An alternative method for estimating utilisation of health services, and health events in general, that could produce more robust results is the use of count data models. A few studies have used count data models to explain different health outcomes. However, only two studies were found using these models to estimate health care utilisation and demand for health care by the older population group (Pagán and Puig, 2005; Korten et al. 1998).

Count data methods were generated in order to model events, the number of times that such event happens, and the duration of the events when they happen. These methods are defined for cases where the dependent variable is a non-negative integer outcome, such as number of days, a score, and number of trips, among many others. Health service utilisation is frequently recorded in surveys as counts or number of times the event or service was demanded by an individual, such as number of times that they visited a physician, number of nights spent in hospital, or number of times they had a dental appointment.

Several authors have noted how in cases where the outcome variables are non-negative integers with a high frequency of zeros, the use of linear regression models can result in inefficient, inconsistent, and biased estimates (Cameron and Trivedi, 2005, 2008; DeMaris, 2004; Long and Freese, 2006). For example, Greene (2008) notes how the preponderance of zeros and small values, as well as the discrete nature of the outcome suggest that there are ways to improve over an OLS linear model with specifications that take these characteristics into account. Thus, the main step consists in finding a probability distribution function that more appropriately defines the data. Count data models have been suggested as one of the main solutions.

One of the first and most common alternatives used is the Poisson regression model (PRM) defined by the Poisson distribution for the number of counts or occurrences of an event, and has the following probability function:

$$\Pr[Y = y] = \frac{e^{-\mu} \mu^y}{y!}$$

where $y = 0, 1, 2, \dots$, μ is the intensity or rate parameter, that is, the expected number of times an event will occur in a given period. The distribution is noted as

$$P[\mu] \quad \text{and the first moments are } \begin{matrix} E[Y] = \mu \\ V[Y] = \mu \end{matrix}.$$

The later show one of the main assumptions of the PRM, the equidispersion property of equality of mean and variance. The PRM has a second main assumption that states that all events occur independently over time. However, both assumptions are difficult to hold in every day examples and many areas of study and utilisation of health services are clear examples of this.

Given that most data on utilisation of health services has a large amount of zeros and tends to be over-dispersed, the Poisson model, assuming equality of mean and

variance, will fail to account for this and will produce incorrect estimates. Also, it is clear that one visit to the doctor or night spent in the hospital may easily depend on past visits and thus, the second assumption does not hold.

Thus, although Poisson models are seen as a good point of departure when exploring count data models, these should be tested and closely analysed. The main method to do this is by estimating an over dispersion (Cameron and Trivedi, 2008; Winkelmann and Zimmermann 1995). Thus, after running the Poisson regression model, PRM one needs to test for:

$$H_0: \alpha = 0$$

$$H_1: \alpha \neq 0$$

Another way of testing the fit of the PRM is to compare the actual and predicted frequencies for the outcome variable²⁵. If H_0 is rejected and $\alpha \neq 0$ this means that the outcome variable presents over dispersion and the PRM will be deficient (Cameron and Trivedi, 2008). Thus, an alternate distribution function should be used.

An example of a model that can be used in order to treat the over dispersion is the Negative Binomial regression model (NBRM) which includes unobserved individual heterogeneity as an error term to the Poisson model. There are many mechanisms to obtain the Negative Binomial density (Cameron and Trivedi 2005). Here we present the negative binomial density that is used most frequently in the literature (Cameron et al. 1998; Cameron and Trivedi, 2005; Long and Freese 2006), and is a

mixture density:
$$P(y|x) = \frac{\Gamma(y + \alpha^{-1})}{y! \Gamma(\alpha^{-1})} \left(\frac{\alpha^{-1}}{\alpha^{-1} + \mu} \right)^{\alpha^{-1}} \left(\frac{\mu}{\mu + \alpha^{-1}} \right)^y$$
 where $\mu = \frac{1}{\delta}$, $\Gamma(\cdot)$ denotes the gamma integral function. Special cases of the negative binomial include the Poisson when $\mu=0$, and the geometric case when $\mu=1$. Additionally the NB presents

$$E[y | \mu, \alpha] = \mu,$$

a variance that exceeds the mean $V[y | \mu, \alpha] = \mu(1 + \alpha\mu)$ since $\alpha \neq 0$, and $\mu \neq 0$

The NB provides a solution to treat over dispersion. However, this may not be enough in special cases such as those where over dispersion is present due to an excess amount of zeros in the data. The presence of more zeros in the data than

²⁵ Additionally, Long and Freese's (2006) *SPost* commands, for use with Stata10 (StataCorp 2007) produce plots of the outcome predicted and actual frequencies as well as of the overall fit of the model. This is useful in evaluating the most appropriate model but all possible evaluation methods should be used.

predicted by count models such as the Poisson and the NB has been defined as the problem of excess zeros (Cameron and Trivedi, 2005; Greene 2008).

Two types of model are frequently used to solve the problem of excess zeros in the data, two-part or Hurdle models and zero-inflated models. Two-part models relax the assumption that the zeros and the positives come from the same data-generating process, and zeros and the positive counts come from a separate density. In this process, maximum likelihood estimation of the two-part models involves a separate maximisation of two separate terms, one for the zero counts and one for the non-zero positive counts (Cameron et al., 1988; Cameron and Trivedi, 2008).

On the other hand, zero-inflated models include two densities, a count density, and a binary process density. This allows zeros to be estimated by two different processes; as a product of the binary process and as a product of the count process when the binary random variable takes value 1. Zero-inflated models define the density of the binary process to be a logit model, while the count density is defined as a Poisson or NB density, generating the zero-inflated Poisson (ZIP) or zero-inflated negative binomial (ZINB) models respectively. These allow for individuals who are "always zero" to be modelled independently of those who can potentially be a zero or any positive count.

Several tests have been developed in order to establish which model best fits the data. On one hand, nested models such as the Poisson and NB can be tested using likelihood ratio tests, while the Akaike information criterion, AIC and Bayesian information criterion, BIC tests can be used to compare both nested and non-nested models. Vuong proposed a test statistic to compare non-nested models, in this case the NB and ZINB (or the PRM against the ZIP) (Vuong, 1989).

Akaike's information criterion, AIC is defined as $\frac{\{-2 \ln \hat{L}(M_k) + 2 P_k\}}{N}$ where $\hat{L}(M_k)$ is the likelihood of the model and P_k is the number of parameters in the model. All things equal, the model with smaller AIC is considered the better-fitting model (Long and Freese 2006).

The Bayesian information criterion, BIC is defined in at least three ways. The most frequently used and which is included in Stata estimations is defined by

$BIC = -2 \ln \hat{L}(M_k) + df_k^s \ln N$ where df_k^s is the number of parameters in the

model, $\hat{L}(M_k)$ is the likelihood of the model, and N is the sample size (Long and Freese, 2006). Finally, the Vuong test considers two models where $\hat{Pr}_1(y_i|x_i)$ is the predicted probability of observing y_i in the first model, and $\hat{Pr}_2(y_i|x_i)$ is the predicted probability for the second model.

$$\ln \left\{ \frac{Pr_1(y_i|x_i)}{Pr_2(y_i|x_i)} \right\}$$

The BIC test is defined by where \bar{m} is the mean

and S_m the standard m_i deviation of The Vuong statistic tests the

hypothesis that $E(m) = 0$ equals $V = \frac{\sqrt{N\bar{m}}}{S_m}$ which is asymptotically distributed as standard normal. If $V > 1.96$, the first model is favoured and if $V < -1.96$ the second model is favoured.

7.4.1 Statistical analysis

Given that in the three selected services a substantial proportion of the respondents used no services and that the distribution of these outcome variables is highly skewed, count data models were selected to explore health services utilisation in this sample of the older Mexican population.

A preliminary step in the analysis of the data was to explore the frequencies and distribution of the three outcome variables to check for over dispersion and probable excess zeros in the data.

After the exploratory analysis of the outcome variables, the next step in the analysis was to estimate the PRM and NBRM and the before mentioned test. In order to explore if the NBRM is the most accurate model or if a two-stage process model could be more accurate to describe the fact that the MHAS data on use of health care services contains many zero values, zero-inflated negative binomial models (ZINB) were also estimated and compared to the NBRM for each dependent variable included in the study. This comprises the second step in the analysis.

As a third step, the results of the PRM, NBRM, and ZINB models were tested to explore the best fit for the Mexican data. The following econometric methods, likelihood tests, Akaike information criterion (AIC) and Bayesian Information criterion (BIC) tests were used to compare the PRM with the NBRM, while the AIC, BIC, and Vuong test were used to compare the performance of the NBRM to that of the ZINB model. All the analyses were performed using STATA10 (StataCorp 2007) statistical software.

As mentioned in previous chapters, this study seeks to make inferences about the population 50 years and older in Mexico, and thus, in the light of missing values in several variables, in addition to estimations for complete-cases, all models were re-estimated using a full sample. In order to do so, the Imputation by Chained Equations, ICE method and the *mim* programme for manipulation and estimations of the imputed data sets were used. These programmes have been developed to use with the Stata10 (StataCorp 2007) software. The percentage of missing values for each variable is presented with the rest of the descriptive statistics in Table 7.1.

Given that important differences were found between men and women regarding their health, frailty, and survival status, all models were estimated separately for men and women. Differences found in these estimations led to several interaction effects being included in the models estimated on the pooled data. The statistical significance of the coefficients of these interaction terms is used to test whether the groups differ or not.

7.5 Data and study sample

As with the rest of this thesis the Mexican Health and Ageing Survey, MHAS was used. Of the 15,186 respondents to the 2001 MHAS survey, 1032 proxy interviews were dropped from the sample as most health and frailty status questions are self-assessed and therefore proxy interviews omit the most relevant information. Additionally, given that the MHAS study includes a sample of respondents 50 years and older and their spouse regardless of their age, those individuals younger than 50 years were also dropped from the sample as the interest of the study is with the population 50 years of age and older.

The final working sample for this analysis consists of 12,477 individuals of which 54.17% are women and 66.6% are living in urban localities with population of more than 100,000. Of this sample, 24.9% of individuals have no formal education (3,105), 53.3% completed Primary education (6,648), and 21.78% completed at least Secondary education (2,716). Regarding their marital status, 69% of the

sample was married or living with a partner, while 31% (3,819) were single including divorced, separated, or widowed. The descriptive statistics of the variables used in the analyses are presented in Table 7.1 and are detailed further below.

Dependent Variables

Outcome variables in the study are related to the utilisation of three types of health care services: medical visits with a general practitioner or specialist including follow-up consultations, outpatient surgery or other procedures, and nights spent in hospital. Specifically, the survey asks if the respondent has had any contact with a particular health service in the year previous to the survey as follows: In the *last year*, about how many times... a) have you had outpatient procedures, not counting stays in the hospital, and b) have you visited or consulted a doctor or medical personnel. The question referring to nights spent in hospital is a separate item asking for all hospital stays in the past year, how many nights did the respondent stay in a hospital overnight.

Independent Variables

Following Andersen's behavioural model of health services utilisation (Andersen 1968, 1995, 2005), there are three types of explanatory variables included in the analyses, which have been widely used in previous literature on the determinants of health utilisation. First, predisposing components are those that show a family or in this case an individual's propensity to seek medical care. In this sense, socio-demographic characteristics such as a person's age, sex, living arrangements, educational achievement, occupation, and ethnic background.

The second component refers to enabling characteristics which capture differences in access to health care such as economic resources and income. Enabling variables included in the analyses are individual income, social security and health insurance status, and size of locality of residence as a proxy of type of medical services available and more or less developed regions in the country.

Finally, assuming the presence of predisposing and enabling conditions, the individual has to perceive being ill in order for him/her to seek health services. Therefore, it is expected that these variables will capture the need for health care and social support. Need variables included in the analyses are represented by a Frailty Index which is a comprehensive measure of health status of the sample population. The Frailty Index and its generation are detailed in Chapter 3. There are two variables included which reflect social support, receiving help with at least one

Activity of Daily Living, ADL and receiving help with at least one Instrumental Activity of Daily Living, IADL.

It is expected that all predisposing variables will have different effects on an individual's behaviour towards health service utilisation. It is hypothesised that older population groups, especially the oldest old will exhibit higher use of services. Given that it was observed that women in the sample accumulate a higher number of health deficits and their usually greater contact with health institutions, higher utilisation by them could be expected. Different socio-economic characteristics such as income or education have been shown to have mixed or contradictory effects on health service utilisation in different studies, while ethnic background or belonging to an indigenous group is expected to have a negative effect given their overall disadvantaged conditions.

Regarding enabling characteristics, income is included in the analysis and it is expected to have a positive and significant effect on utilisation. In line with other studies, insurance status is considered as a main enabling factor for use of services independent of predisposing and need factors. This is hypothesised to be of special relevance in the case of Mexico where there is no universal insurance coverage and thus having any insurance is expected to encourage access to services (Wallace and Gutierrez, 2005). Also, living in a more urban area (population of 100,000+) is expected to have a positive effect on the propensity to use services mainly due to higher access to health clinics and other medical facilities. Finally, it is hypothesised that as an individual accumulates more health deficits or conditions he/she will be more prone to seek health care, and it is expected that these are among the most important determinants in the model.

7.6 Results

After conducting an exploratory analysis of the three outcome variables to be used in the estimations and plotting their frequencies, it can be noted that the three dependent variables have variances that are much higher than their mean, and they are highly skewed (Table 7.1).

Table 7.1 Frequency distribution and moments of outcome variables

Outcome	observations	mean	std dev	variance	skewness	kurtosis	min	max
Inpatient	12,453	.6930	4.6	21.15	16.4	366	0	150
outpatient	12,467	.0309	.6187	.3827	48.9	3239.15	0	48
medical visits	12,437	4.25	7.4	54.5	9.7	193.24	0	210

After this exploratory analysis, the Poisson regression, PR and Negative Binomial regression models were estimated. Additionally, tests of over dispersion of the Poisson regression model and of the overall fit of the models were performed.

Results of estimating the models and the likelihood-ratio test of $\alpha \neq 0$ for the three outcomes are presented in Table 7.2. It can be clearly seen that the assumption of equidispersion is not met in any of the models, with a high significance level for the test for all three models.

Table 7.2 Likelihood test of equidispersion ($\alpha \neq 0$)

	nights in hospital	medical doctor visits	outpatient proc.
chi ² (01)	2.9e+04	1.4e+04	448.93
Prob. >=chi2	0.000	0.000	0.000

Besides strong evidence of over dispersion, the tests of the fit of the PRM vs. NBR models for number of nights spent in hospital, medical doctor visits, and ambulatory procedures in Table 7.3 below show a much better fit of the NBRM as all the tests included: AIC, BIC and the likelihood ratio test favour the NBRM over the PRM. This is also observed in the plot of the fit of the models. Thus the NBRM is preferred over the Poisson model.

Table 7.3 Tests and model fit statistics of PRM vs. NBRM (Frailty Index)

Outcome	BIC	AIC	LRX2	Tests' preferred model
<i>nights spent in hospital</i>				
Poisson Regression, PRM	-28269.898	3.606		All tests favour NBRM over PRM
Negative Binomial, NBRM	-42439.619	1.094		
PRM vs. NBRM	-42439.619	1.094	14178.359 p=0.000	
<i>outpatient procedures including surgery</i>				
Poisson Regression, PRM	-46589.766	0.367		All tests favour NBRM over PRM
Negative Binomial, NBRM	-47030.061	0.288		
PRM vs. NBRM	-47030.061	0.288	448.934 p=0.000	
<i>physician visits including follow-up consultations</i>				
Poisson Regression, PRM	-2336.88	8.19		All tests favour NBRM over PRM
Negative Binomial, NBRM	-21304.06	4.83		
PRM vs. NBRM	-21304.06	4.83	18975.82 p=0.000	

As mentioned earlier, NBRMs could also present problems, they are especially likely to under predict zeros and over predict ones. In these cases, zero-inflated models could be a better option. In order to explore if the NBRM provided the best fit, zero-inflated negative binomial models, ZINB were run for each of the outcomes and tested against the NBRM.

The results for the models of nights spent in hospital and medical doctor visits are quite similar, while the ZINB estimation for outpatient procedures did not converge. Therefore, the NBRM was selected to estimate the model for outpatient procedures.

Table 7.4 shows the results for inpatient hospital services (nights spent in hospital). Here the BIC favours the NBRM over the ZINB while the AIC and the Vuong test favours the ZINB model. With respect to medical doctor or physician visits all three tests favour the ZINB model.

Table 7.4 Test and model fit statistics of NBR vs. ZINB models, nights spent in hospitalⁱ

Outcome	BIC	AIC	Vuong	Tests' preferred model
<i>nights spent in hospital</i>				
Negative Binomial, NBRM	-42439.619	1.094	4.993 p=0.000	The BIC favours the NBRM over the ZINB, while the AIC and the Vuong test favour the ZINB model
Zero-Inflated Negative Binomial, ZINB				
NBRM vs. ZINB	-42397.234	1.078		
<i>physician visits including follow-up consultations</i>				
Negative Binomial, NBRM	-21304.068	4.833	7.832 p=0.000	All the tests favour the ZINB over the NBR model
Zero-Inflated Negative Binomial, ZINB				
NBRM vs. ZINB	-21398.246	4.793		

It is desirable to compare the complete-case analyses and those performed using the multiple imputed data sets. However, the `mim` command for performing regression estimates with multiple imputed data sets does not support zero-inflated models and only allows for Poisson and Negative Binomial regression in terms of count data models. Thus, after analysing the results of the Poisson regression models and their tests, and given the arguments presented above, Negative Binomial regression methods were selected for the three outcomes of interest.

7.6.1 Predictors of outpatient hospital service use

Table 7.5 presents the results of the Negative Binomial regression estimates for outpatient procedures for the complete-case and the multiple imputation analyses. The fourth column in the complete-case analysis presents the marginal effects, which reflect the impact of a discrete change (from 0 to 1) for each explanatory variable on having an outpatient procedure, holding all other covariates at their mean.

It is interesting to see how need variables, expressed by the level of frailty of the individual, impact significantly on the probability of utilisation of these services and is the most important predictor of having any outpatient procedure. Although there is not a perfect linear trend, all the coefficients are large, positive, and statistically significant.

However, although frailty status appears to be significant in the complete case analysis, this remains true only for individuals in the highest frailty quartile once the multiple imputation procedure is implemented. Given that the some of the

variables with highest level of missing values are used for the construction of the Frailty Index, these results could reflect that the latter estimations are more robust.

Table 7.5 Predictors of outpatient procedures MHAS 2001

variable	complete-case analysis				multiple imputation analysis		
	coefficient	std. error	P> z	dy/dx	coefficient	std. error	P> t
male	0.539	0.252	0.032	0.016	-0.691	0.474	0.145
60-69 years old	-0.054	0.233	0.817	-0.002	-0.057	0.199	0.775
70+ years old	-0.167	0.326	0.609	-0.005	0.378	0.230	0.100
population 100,000+	0.656	0.269	0.015	0.017	0.351	0.262	0.181
male*pop 100,000+					0.621	0.375	0.099
Income q2	0.282	0.363	0.438	0.009	-0.393	0.356	0.270
Income q3	-0.499	0.378	0.187	-0.013	-0.310	0.351	0.378
Income q4	0.449	0.327	0.170	0.015	0.358	0.341	0.293
Income q5	0.671	0.323	0.038	0.024	0.197	0.349	0.573
male*Income q2					0.686	0.571	0.230
male*Income q3					1.004	0.534	0.060
male*Income q4					0.343	0.511	0.502
male*Income q5					1.335	0.511	0.009
receives help ADLs	1.442	0.726	0.047	0.095	0.435	0.533	0.415
receives help IADLs	0.434	0.575	0.451	0.016	0.047	0.398	0.907
indigenous language	1.013	0.821	0.217	0.050	0.649	0.442	0.142
male*indig lang	-3.115	1.378	0.024	-0.032	-2.279	0.841	0.007
completed primary	0.336	0.331	0.310	0.010	-0.047	0.213	0.825
at least secondary	0.616	0.373	0.098	0.021	0.038	0.269	0.889
single	0.249	0.240	0.301	0.008	-0.051	0.200	0.801
insured	-0.080	0.237	0.737	-0.002	0.003	0.192	0.989
works	-0.159	0.239	0.506	-0.005	-0.347	0.197	0.078
Frailty Index q2	0.886	0.294	0.003	0.034	0.379	0.313	0.231
Frailty Index q3	0.758	0.305	0.013	0.028	0.446	0.272	0.102
Frailty Index q4	1.183	0.314	0.000	0.051	0.805	0.255	0.002
_cons	-5.437	0.529	0.000		-4.169	0.387	0.000
/lnalpha	3.095	0.156			3.725	0.105	
alpha	22.085	3.449					
observations	5648						
dispersion	mean						
Log likelihood	-787.83						
LR chi2(20)	60.4						
Prob>chi2	0.000						
Pseudo R2	0.037						
imputations					10		
minimum obs.					12220		
minimum degrees-freedom					58.8		

Likelihood-ratio test of alpha=0: $\chi^2(01) = 447.76$ Prob>=chi2 = 0.000

Receiving help with at least one activity of daily living has a positive effect on having outpatient procedures although only significant at the 5 percent level. Its marginal effect suggests that if an individual receives help with ADLs, the likelihood of having outpatient procedures increases by a factor of 0.095, while holding all the other explanatory variables constant.

The results show that age is not a significant determinant of having outpatient procedures, quite the contrary; the coefficients are negative for the two age group categories, and remains so for the 60-69 year old group in the multiple imputation analyses.

Living in a community with a population of 100,000 or more has a positive and significant effect on having outpatient procedures, although the coefficients are only significant for the complete-case analyses.

Finally, the results show that speaking an indigenous language (as proxy of indigenous ethnic background), has a large negative and highly significant effect on men, both in the complete-case ($p=0.024$) and in the multiple imputation ($p=0.007$) analyses. The marginal effects in the complete-case analysis show that being a man that speaks an indigenous language decreases the likelihood of having an outpatient procedure by a factor of 0.032, while holding all the other explanatory variables at their mean.

In sum, the results show how although need is the most significant determinant of having outpatient procedures, two enabling factors, living in a more urban area and receiving help with ADLs, are also important determinants, followed by one predisposing factor, ethnic background.

7.6.2 Predictors of spending nights in hospital (inpatient services)

The results of the estimation of the determinants of spending nights in hospital are presented in Table 7.6.

One of the main results of these analyses was that age only turned out to be significant for men who are in the oldest age group, 70 years and older. This can be noted by the coefficient and significance of the interaction variable of being male and in this age group.

Besides age and sex, the only variable that turned out to be a significant determinant of spending nights in hospital is having an employment outside the household for men. Although the overall results of paid employment are not significant and the coefficients are small, the coefficients for both the complete-case and multiple imputation analyses for the interaction of being male and employed turn out to be large, negative, and statistically significant at the .01 level.

Table 7.6 Predictors of nights spent in hospital, MHAS 2001

variable	complete-case analysis				multiple imputation analysis		
	coefficient	std. error	P> z	dy/dx	coefficient	std. error	P> t
male	0.826	0.256	0.001	0.348	0.330	0.219	0.131
60-69 years old	-0.052	0.180	0.774	-0.022	0.109	0.164	0.506
70+ years old	0.132	0.239	0.582	0.059	-0.103	0.195	0.597
male*60-69 yrs					0.208	0.238	0.381
male*70+ yrs					0.616	0.274	0.025
population 100,000+	0.017	0.187	0.926	0.007	0.048	0.116	0.680
income q2	-0.022	0.268	0.934	-0.009	0.001	0.162	0.996
income q3	-0.095	0.253	0.706	-0.040	-0.243	0.155	0.117
income q4	0.137	0.235	0.562	0.061	0.007	0.153	0.964
income q5	0.331	0.240	0.168	0.155	-0.001	0.155	0.994
receives help ADLs	-0.048	0.670	0.943	-0.020	0.557	0.333	0.095
receives help IADLs	1.263	0.455	0.006	1.053	0.986	0.239	0.000
indigenous lang	-0.492	0.369	0.182	-0.171	0.206	0.207	0.320
completed primary	-0.173	0.223	0.437	-0.075	0.141	0.125	0.260
at least secondary	-0.067	0.262	0.800	-0.028	0.204	0.169	0.228
single	0.063	0.180	0.727	0.027	0.024	0.120	0.843
insured	0.859	0.168	0.000	0.325	0.850	0.110	0.000
works	-0.024	0.236	0.918	-0.011	0.122	0.171	0.478
male*works	-0.816	0.326	0.012	-0.337	-0.897	0.233	0.000
Frailty Index q2	0.562	0.222	0.011	0.284	0.396	0.172	0.023
Frailty Index q3	0.921	0.224	0.000	0.520	0.942	0.154	0.000
Frailty Index q4	1.529	0.226	0.000	1.069	1.588	0.160	0.000
_cons	-2.310	0.354	0.000		-2.270	0.225	0.000
/lnalpha	3.265	0.056			3.228	0.037	
alpha	26.174	1.458					
observations	5644						
dispersion	mean						
Log likelihood	-3063.7						
LR chi2(23)	124.56						
Prob>chi2	0.000						
Pseudo R2	0.0199						
Imputations					10		
min. obs.					12220		
min dof					109.1		

Likelihood-ratio test of alpha=0: chi2(01) = 1.4e+04 Prob.>=chi2 = 0.000

Need factors expressed in the frailty status variables show large, positive, and statistically significant coefficients that additionally show an increasing linear trend. Thus, as individuals become frailer, their likelihood of spending nights in hospital increases. In addition to high frailty status, two enabling factors show high relevance as determinant factors of spending nights in hospital, receiving help with IADLs and being insured. We observe this both for the complete-case and the multiple imputation analyses. In the case of receiving help with IADLs, the marginal effects show that the likelihood of spending nights in hospital for this population group increases by a factor of 1.053 while holding the rest of the independent variables constant at their mean.

In sum, these results show that need is again the most significant predictor of using hospital services and the number of nights spent in hospital. This is expressed by the coefficients and significance of the frailty status of the individuals. With the exception of working status and age all other predisposing variables did not turn out to be significant, while receiving help with IADLs and being insured are two enabling characteristics with a highly significant effect on use of these services.

7.6.3 Predictors of medical doctor consultations

The results for the complete-case and the multiple imputation analyses of visiting a medical doctor or physician are presented in Table 7.7.

Table 7.7 Predictors of medical doctor visits, MHAS 2001

	complete-case analysis				multiple imputation analysis		
variable	coefficient	std. error	P> z	dy/dx	coefficient	std. error	P> t
male	-0.320	0.055	0.000	-1.202	-0.425	0.076	0.000
60-69 years old	-0.007	0.063	0.917	-0.024	0.042	0.041	0.311
70+ years old	0.000	0.090	0.996	-0.002	-0.054	0.050	0.277
male*60-69 yrs	0.182	0.085	0.032	0.709	0.200	0.061	0.001
male*70+ yrs	0.276	0.111	0.013	1.135	0.344	0.069	0.000
population 100,000+	-0.072	0.045	0.111	-0.269	-0.122	0.040	0.002
male*pop 100,000+					0.119	0.057	0.039
income q2	-0.054	0.067	0.419	-0.195	0.119	0.054	0.028
income q3	0.037	0.061	0.551	0.136	0.166	0.053	0.002
income q4	0.121	0.059	0.041	0.459	0.238	0.054	0.000
income q5	0.037	0.060	0.538	0.136	0.137	0.056	0.015
male*income q2					-0.142	0.086	0.101
male*income q3					-0.132	0.082	0.108
male*income q4					-0.196	0.081	0.016
male*income q5					-0.098	0.082	0.230
receives help ADLs	-0.027	0.230	0.905	-0.100	-0.001	0.108	0.994
male*help ADLs	1.238	0.377	0.001	8.947	0.573	0.176	0.001
receives help IADLs	0.067	0.135	0.621	0.253	0.091	0.064	0.156
male*help IADLs	-0.671	0.319	0.036	-1.800			
indigenous lang	-0.303	0.091	0.001	-0.973	-0.147	0.056	0.008
completed primary	0.046	0.055	0.398	0.170	0.116	0.033	0.000
at least secondary	0.094	0.064	0.141	0.349	0.121	0.044	0.006
single	-0.004	0.045	0.930	-0.014	-0.154	0.031	0.000
insured	0.685	0.044	0.000	2.259	0.660	0.030	0.000
works	-0.179	0.042	0.000	-0.667	-0.207	0.035	0.000
Frailty index q2	0.516	0.054	0.000	2.188	0.336	0.041	0.000
Frailty index q3	0.832	0.054	0.000	3.886	0.624	0.039	0.000
Frailty index q4	1.046	0.055	0.000	5.249	0.924	0.041	0.000
cons	0.447	0.091	0.000		0.584	0.062	0.000
/lnalpha	0.483	0.025			0.569	0.017	
alpha	1.621	0.041					
observations	5637						
dispersion							
Log likelihood	-13590.6						
LR chi2(23)	816.82						
Prob>chi2	0.0000						
Pseudo R2	0.029						
imputations					10		
minimum obs.					12220		
minimum dof					98.3		

Likelihood-ratio test of alpha=0: chi2(01) = 1.9e+04 Prob.>=chi2 = 0.000

A review of predisposing factors shows that men have a negative and statistically significant probability of consulting a medical doctor compared to women, and their likelihood of using these services decreases by a factor of 1.202 while holding the rest of the independent variables constant at their mean. The results are similar with the multiple imputation analyses where the coefficient is larger and equally significant.

The overall effect of age did not turn out to be significant. However, male-age interaction effects are positive and statistically significant both in the complete case and in the multiple imputation analyses. The linear increasing trend shows that while for women age is not significant determinant of their seeking a consultation with a physician, for men, age is a strong determinant with a probability of them using this health service increasing as age increases.

Regarding the other predisposing variables included in the estimations, educational attainment did not have any effect on determining utilisation of physician services, while ethnic background in terms of speaking an indigenous language turned out to have a negative and statistically significant effect on seeking physician services both in the complete-case and multiple imputation analyses. Looking at the marginal effects in the complete case analyses, we can see that the marginal effect of this variable is one of the largest in the model showing that the likelihood for this group of seeking physician services decreases by a factor of 0.973 while holding the rest of the independent variables constant at their mean.

Turning to enabling factors for seeking care, there seems to be an overall positive and significant effect of income on the probability of consulting a medical doctor in the multiple imputation analyses. However, the results are quite different for men and for women. The interaction variable between sex and income shows that for men the effect of income is negative and not significant with the exception of the fourth quintile of income (next to last highest income quintile).

Being insured and thus, having higher access to medical services is highly significant both in the complete-case and the multiple imputed analyses. The coefficient is positive and highly significant while the marginal effects show that if an individual is insured, the likelihood of consulting a medical doctor increases by a factor of 2.259. Additionally, having a job outside the household shows a negative and statistically significant effect on utilisation of physician services in the complete-case and multiple imputation analyses. The marginal effects for the complete case analyses show that working decreases the likelihood of consulting a

medical doctor by a factor of -0.667 while holding the rest of the independent variables at their mean.

It is interesting to find how receiving help has a different effect for men and women in their seeking medical consultations. While the overall effect for receiving help with ADLs and with IADLs is not significant, there is a significant difference between men and women. This is true for both the complete-case and the multiple imputation data sets. Men receiving help with ADLs show a larger positive and statistically significant probability of seeking medical consultations than women. On the other hand, men receiving help with IADLs have a lower probability than women of seeking medical consultations.

Finally, regarding enabling factors, it is interesting to see how being single is a negative determinant of seeking physician consultations, although the results are only significant for the multiple imputation analyses.

With respect to the indicator of need, as expected, frailty status is a positive determinant of utilisation of physician services. As individuals become frailer they show a higher probability of seeking consultations and a clear increasing trend in the coefficients. In accordance with this, the likelihood of consulting a medical doctor, expressed by the marginal effects, clearly increases as individuals have higher frailty.

7.7 Discussion

In this study we investigated the utilisation of three types of health services by a nationally representative sample of individuals 50 years and older in Mexico. The conceptual framework that the study follows is the model generated by Andersen (1968). Although this model was later modified to include general and community level characteristics of the health care delivery system, because in Mexico there are no comprehensive health and social services for older population groups, and the survey does not include detailed information on the delivery of services for them, the original model was used.

Following the model, the selected variables and the analyses use the original three components of the model, predisposing, enabling and need factors. To my knowledge this is one of only two studies using the MHAS data set to study utilisation of health services by the Mexican older population, and the first one that uses methods that allow not only likelihood of use to be modelled but also the determinants of the intensity of such use by using count data models.

Although results are not comparable with other studies given the large difference in the samples studied and of the health and social services systems, it was interesting to see how some results are similar. In contrast with most of the previous empirical work on health service utilisation by older population groups, this study uses a nationally representative data set of the population 50 years and older in Mexico. Additionally, compared to these studies that use complete-case analyses only, by generating a multiple imputation procedure and using multiple imputation techniques to compare the results and reduce the likelihood of bias or incorrect results, this study adds to the scarce literature on applied multiple imputation in the field of health and health care.

Given that there are no social services for the older population group in Mexico, besides need, enabling factors such as income, locality of residence, and marital or partnership status were of special interest in predicting utilisation of health services. The main interest refers to equity in access to services and an equitable distribution of services within the health system.

Results show that need factors are one of the most important determinants of utilisation of all three health services. However, other factors, especially enabling characteristics also turned out to be highly significant.

In the review of previous studies of utilisation of health services both in Mexico and in other countries it was seen how women have a higher likelihood and frequency of use of physician services while men have higher probability of going into hospital both as inpatients and for ambulatory outpatient procedures. In Mexico women have higher contact with health clinics and health practitioners and these results clearly show that. This result could additionally be reflecting how although women accumulate more deficits than men, the latter show higher risk of mortality and probably also higher risk of complications or sudden interventions which require such services.

The fact that age is not a significant determinant except for older men (70 years and older) is interesting and the negative effect most coefficients show could suggest that for these services it is not age, but frailty and health status that determine utilisation. In terms of future services this is important because as noted previously, a high proportion of the ageing population in Mexico presents at least one but more likely a combination of chronic illnesses that could in the future pose a much higher strain on these health services.

In addition to frailty status receiving help with ADLs was a significant determinant of having outpatient procedures, while receiving help with IADLs was significant for the case of nights spent in hospital suggesting that those who have someone to help them are more likely to utilise these services. This may be closely related the public health system generally relying on the patients having a family or close network member to take care of and be responsible for them.

This result is significantly relevant in more than one way. First, it provides evidence of the important role that family and social support play in the overall health and well-being of older adults in Mexico. Second, it gives an important input to future planning of health and social policies. These policies should take this into account in order to provide adequate support that reflects the needs of the older individual regarding health and social services, such as home care. Policies also need to recognise the excess burden on family and network members in terms of their opportunity costs forgone.

Together with earlier results on the supply of informal care for this population, these results suggest that there is a need for an in-depth assessment of family and social networks available to the older population in Mexico, of who is caring and at what cost.

Another related important issue that will be discussed in detail in chapter 8 is the relation between informal care (usually un-paid) and use of formal (publicly funded) services, in the case of Mexico, of health services. Some of the key questions are whether these types of care are independent or if they complement each other, and how current literature has mixed positions on the effects of informal care on formal care utilisation. Equally, findings vary widely and often show contrasting results regarding the substitution effects between informal and formal care giving.

Although there is no formal long-term care, home-care, or other social services for the older population in Mexico, the possible substitution or complementarity between the supply of informal care for this group of population and their use of health service remains an issue.

Wong and Diaz (2007) also found that enabling factors, such as being insured, size of locality of residence and ethnic background are highly significant determinants of utilisation of services. These results suggest how inequity of access and differences in utilisation of health services reflect the high inequalities in socioeconomic conditions in Mexico. This is highly relevant and should also be taken into account in the future planning of health and social services that cater to the older

population groups so as to identify these inequalities and work to reduce or eliminate them.

In sum, this study has demonstrated how besides need, enabling characteristics are highly relevant determinants of utilisation of health services by the older population in Mexico. It has shown how differences in access to services and socioeconomic conditions seem to play a fundamental role in this. This study is relevant in addition because for the first time information on utilisation services by a representative sample of the population 50 years and above is analysed. This allows for the development of strategies aimed specifically at this group.

Nonetheless, there are some methodological and data collection limitations to the study.

First, time period of the data and the effect time may have on some covariates and in turn, on the estimations should be considered. For example, while some health indicators such as self-reported health reflect the status of the individual on the day of the survey, others reflect long-standing conditions, such as rheumatoid arthritis, diabetes and other chronic diseases. Thus, one may expect their effect on health utilisation to be different and mediated by different factors.

Also, there are issues regarding possible simultaneity and correlation between the use of the different services included in the study and how the use of services is initiated (patient or medical personnel), which cannot be addressed by estimating the equations separately. Thus, while first contact may be due to a fall, subsequently there may be hospital stays and follow-up visits which all relate to the same event but involve the use of different services. Unfortunately, MHAS only asks if the respondent used the services and number of times but not the underlying reason or condition that led the respondent to seek services. A way to address this problem would be to estimate the three types of services through a system of simultaneous equations and try to determine if one service is causing the other.

In addition, possible issues of causality between the utilisation of health services and the illness or event that causes the use of services may clearly arise. Given that this study is cross-sectional, it is not possible to determine if health status or health conditions are determining the use of services or if health status is a direct consequence of use of services. Therefore, the issue of causality could not be addressed and the interpretation of the results should take this into consideration. It is to be hoped that future waves of the MHAS will follow and then longitudinal data will allow dynamic analyses that investigate transitions between an individual's

health status from one period to the next and consequently investigation of the causes of the utilisation of services.

As with many other longitudinal surveys on ageing MHAS includes questions on utilisation that ask about use during the last year and this may cause some problems in the estimations. First, it is possible that the respondent was ill or needed services continuously in that year or that that she/he just needed them for some acute condition during that year. In a similar way, there may be issues of causality in the estimations as it is difficult to estimate precisely if the utilisation is reflecting recent acute conditions or long-standing diseases that endured throughout the year in question.

Another issue to consider is the possible endogeneity of some variables included in the study. This means that key variables included in the model that were treated as exogenous might have unobserved effects on the level of utilisation and result in biased coefficient estimates (inconsistent parameters). In addition, issues of causality are likely to arise as utilisation may also influence the variables included in the models. The main variables that might be endogenous or influenced by utilisation of services are some health conditions included in the frailty status, if the person receives informal support in their daily activities, and their insurance status.

Chronic diseases and long-standing conditions such as depression and difficulty with every day activities included in the Frailty Index were used in an earlier chapter as determinants of disability while the Frailty Index was used to predict utilisation of health services which could cause an endogeneity problem. In other words it is difficult to identify clearly which variable is determining what. A way to overcome this would be, for example, to estimate a model of simultaneous equations - one equation of utilisation of services as a function of health characteristics and observed characteristics of the individuals, and a second equation of health status as a function of utilisation of services and health in present and past periods of time, in order to investigate possible simultaneous relations in these two equations and the question of endogeneity.

As will be extensively presented in Chapter 8, understanding the relations between utilisation of formal care and provision of informal care (represented as help received with daily activities in the models) and the effects they have on each other regarding their possible complementary role, simultaneity, or one preceding the other, is not straightforward. This can also cause problems of endogeneity when estimating the models.

There are issues of causality since those that have informal support may use less services given the help they receive (substitution effect), but it may also be the case that because they have someone to help they are more often in contact with the services because they have someone to take them (complementary effect). Thus, informal care may lead to use of formal services, and utilisation of formal services may change the use or need for informal care (for example, lower need due to some treatment received in the formal services, or higher need due to post-surgery care required at home).

A possible way to tackle issues of endogeneity and estimating possible causal relations between formal and informal care is the use of Instrumental Variables methods. This will be discussed in more detail in Chapter 8.

Finally, there are two important factors that may have an effect on utilisation of health services that were not included in the models and therefore the results should be interpreted with these in mind. The first factor is quality of services which has been noted to affect utilisation of health services in different conceptual and empirical studies.

Although studies on quality of services in Mexico are recent, there are some examples that provide relevant information about the perception of the services in Mexico and its impact on utilisation of services. One of the first studies using national level data from the National Health Survey II, 1994 (Ramírez-Sánchez, Nájera-Aguilar, and Nigenda-López, 1998) found that when assessing services users put greatest weight on the inter-personal aspects or dynamics of the health care process, such as the content and duration of the consultation, cordiality, information obtained. Infrastructure, the results of the process, and access to services are also identified. Interestingly, the main cause for not returning to the same institution or health provider was receiving a deficient service and long waiting times.

In addition, two surveys on satisfaction with health services (FUNSALUD 1994, 2000) show similar results. Using the Survey of Satisfaction with the Health Services 1994, Zurita, Nigenda, and Ramírez (1997) found that Mexican adults were not satisfied with the health system and considered that the process is highly bureaucratic, and that the main problems of the health services are bad quality (45%) and lack of resources (29%).

On the other hand, Zurita and Ramírez (2003) note that lack of resources, difficulties in access to services, and bad provision of services were highly reported

by poor adults, those living in rural and semi-urban areas, the non-insured, older adults, and those with chronic illnesses. Regarding quality of services, 80% of respondents had a bad opinion of the services, and more than one third of respondents who received first level services at the Ministry of Health services or at IMSS said they would not go back to the same place. These results clearly show how the perceived quality of services may have relevant effects on the utilisation of health services.

Finally, in a study of the services provided for insured adults 60 years and older by the Mexican Institute of Social Security, Reyes Frausto et al. (2002) found that 67% of the respondents had a good or positive opinion of the services, 28% had a regular/fair opinion, while the remaining 5% had a negative opinion of the services they received. Interestingly, they found marked differences between the states in the north of the country and those in the south, with richer or better off countries (northwest) perceiving services to be of better quality.

The second factor that should be mentioned is access to health services. In Mexico, access to health services in many rural and remote areas is very poor, especially regarding second or third level services for which people in these localities have to travel for anything up to a couple of days. Most services are publicly funded and provided by the Ministry of Health, in many occasions under-funded and with high gaps in infrastructure and equipment. Although more urban areas tend to have more and a greater variety of health facilities, a variable indicating if the area of residence is more or less urban is not a precise indicator of the infrastructure available and therefore not a good indicator of services available and access to them.

Given that access to services should ideally be included in the analyses of utilisation of services, a possible way to overcome the current lack of information in MHAS on local infrastructure and the characteristics of the locality would be to obtain from the National Institute of Statistics, Geography and Informatics, INEGI and local ministries of health relevant information in order to link it to the MHAS data set. Some of the information that could be available includes the number and type of health care facilities, marginality or poverty index of the locality, basic services such as transport, roads, sewerage and availability of potable watery, electricity, among others. This could be used in an analysis of utilisation controlling for different access-to-services covariates.

There are other recommendations for future work that should be mentioned. First, it would be desirable to conduct studies that investigate non-utilisation of services especially since to my knowledge no work of this type has been previously done taking a representative sample of the ageing population in Mexico. In particular, it is necessary to investigate non-demand, when need is present, including measures of access to services, and their quality. In addition, the inclusion of factors such as empowerment or perception of self-control/management of own problems and decisions, which MHAS does include would also be worth exploring as possible determinants of utilisation or non-demand of health care services.

Further waves of the MHAS that create a truly longitudinal study would allow for undertaking studies with additional methods which aim at tackling the before mentioned endogeneity issues, such as instrumental variable techniques, simultaneous equation models, for controlling for confounding variables, as well as undertaking dynamic models for example of the relationship between health status at different points in time and health service utilisation.

As stated in the discussion of the chapter on survival analyses, the fact that the multiple imputation procedures do not allow for all the desired estimation methods constitutes a second limitation of this study. In the case of utilisation of health services, it would be desirable that such procedures would allow for zero-inflated models and being able to test them and compare them with complete-case analyses in future estimations.

Finally, further research on socio-economic inequalities affecting access and health utilisation appears an imminent need especially in the context of future planning and implementation of long-term health and social services for the older population group in Mexico.

Chapter 8 Determinants of the supply of informal care to the older population in Mexico

8.1 Introduction

As Mexico experiences socioeconomic and demographic trends, a rapidly increasing ageing population, increasing labour force participation by women, and high international immigration, among other changes, uncertainty about the provision of health and social care for the older population is becoming a pressing issue. According to official statistics, the percentage of population 65 years and older is estimated to go from almost 7% of total population in 2000 to 15% in 2025 and 28% in 2050. In a parallel process, life expectancy in Mexico increased significantly from 35.9 years in 1930 (34.9 men and 36.9 women), to 75 years in 2006 (72.6 and 77.4 respectively) (Partida Bush, 2004).

Although there are several theories about how the extended life expectancy will be experienced by ageing individuals (expansion or compression of morbidity), it is agreed that as number of years lived increases, the risk of the older population requiring either financial support or care increases. The older population in Mexico as in many other countries are living longer than they ever have. For a number of individuals this will occur alongside increasing frailty both physical and mental, posing extra strain on already scarce resources.

Palloni, Pinto-Aguirre, and Peláez (2002) note that in addition to an absence of public or private institutions that can respond to the changing social and healthcare demands from an older population, for most countries in the region a highly compressed aging process will take place in the midst of weak economies, changing intergenerational relations, and constricting access to medical and health care.

Given the lack of long-term health and social care strategies for the older population in Mexico, health and social development ministries have historically tried to compensate with alternative or palliative strategies to provide services for the older population, and it is clear that the social development and health sectors are unprepared to cater for the needs of the growing older population. This situation has left informal caregivers, mostly women, to take the main responsibility for the provision of household care activities through the life cycle, from early childhood care and family health care, to health and long-term care for the older population.

The National Population Council, estimates that the majority of the population aged 60 years and older in Mexico lives with their children or other close relatives (Zúñiga and García, 2008). Because multi-generational living arrangements are still the norm in Mexico, informal care has an important role with respect to the health status of the older population and their demand for services.

It is known that, particularly in developing countries, the older population group becomes an important factor in terms of household care by simultaneously providing care and receiving care depending on their functional capabilities (Montes de Oca, 1999; Robles-Silva 2008). However, changes in fertility rates, constant rural-urban migration, women's increasing participation in the labour force, among other factors have changed family size and composition and may pose future challenges to the availability of household care and support.

Long-term care services for the older population can be provided formally or informally and provision will depend on the type of broad social and health system in place in each country as well as cultural norms prevalent in each society. Informal care by adult children is a common form of long-term care for older adults and can act as a substitute for or complement to formal care. In the same way, older adults become important providers of care and support within the household.

Informal care has been shown as a means of preventing or decreasing medical expenditures for the older population, preventing further illnesses, and even stopping them falling into poverty. On the other hand, it has been noted to increase participation of older persons in different health and social care programmes as well as their use of services.

Several studies have estimated that between 80% and 90% of the health care needed is provided informally (Grunfeld et al., 2004; Pickard, 2001). In general, informal caregivers are family members, friends, or neighbours who carry out these activities with no payment or compensation in exchange.

For example, La Parra states that of the total hours of care-giving for the ill in Spain health professionals provide 12%, while family members provide 88%. This means that household care has increasingly become the base upon which the Spanish health system is supported (La Parra, 2001).

For Britain, (Wittenberg et al., 1998) using the General Household Survey found that, of all older people that received help with domestic tasks, 80 per cent relied exclusively on informal help by family, household members, friends, etc.

Also, studies have shown how most of these informal carers are women or more disadvantaged groups. Based on the European Household Panel data, La Parra (2001) showed that the responsibility for taking care of the chronically ill, the older population, or disabled, falls mostly on women, the unemployed, population groups with low income, and the older population groups. In another Spanish study, Durán (1999) states that women are in general the main caregivers contributing 300 hours each a year to care giving while men dedicate approximately 190 hours.

In general, household health care is culturally perceived as an extension of domestic tasks and a sector traditionally assigned to family members and close relatives or friends (Tomassini et al., 2004; Pickard et al., 2000). Still, despite their importance and their burden, domestic activities have not been widely recognized as "productive" activities and the issue of household health care has not been widely studied.

Within the literature, there is considerable uncertainty and by no means general agreement about the future of informal care and its availability. Underlying the uncertainty about the future availability of informal care there is a wider social policy issue considered which relates not so much to whether societies can continue to rely on informal care, but whether they should continue to rely on it (Pickard et al., 2000).

Still, this tendency does not seem to be changing, and even in countries with well established Long-term care programmes and policies, informal care for the older population remains the most common form of long-term care. It is often preferred by older individuals to formal and institutional care, and can reduce medical expenditures if it substitutes for formal care. According to Tomassini et al. (2004) family members provide the great majority of care received by older people in most European countries. There is nevertheless considerable variation across countries, with a higher proportion of older people receiving care and living with family members in southern Europe. Moreover, they show there has been little change over time in attitudes towards elder care.

Few analyses of the Mexican health system have considered the fundamental role of the household in the provision of healthcare and other services for the older population. In general, research on the social aspects of ageing is very recent in Mexico and has been limited by a lack of data and first hand information. Together with the imminent ageing of the population and its current and future impact, there is a great need for information on household dynamics, on the social determinants

of the health of the older population, on their need for support and care, on who is taking up such support and caring activities, on the opportunity costs generated in doing so, among other relevant factors.

It is clear that care giving responsibilities cause high opportunity costs, mainly for women, in terms of education, employment, and foregone time spent in personal and leisure activities, policy makers, in particular in the health and social development sectors, should be focusing on current and expected future implications of care for the older population and try to overcome or alleviate these costs.

In order to advance knowledge regarding care giving for the older persons in Mexico, this chapter aims to estimate the characteristics and determinants of the supply of informal care to the older population in Mexico and of the time spent in such activities. In contrast to previous studies of household care in Mexico where appropriate data were not available, for the first time, this study not only explores the older individual's socio-demographic and economic characteristics and their household composition, but also relevant data on resident and non-resident children such as their sex, age, marital status, number of children, financial situation and main occupation. Also, it uses advanced methods of estimation in the hope of obtaining as accurate estimations as possible.

8.2 Conceptual framework

Some of the initial works on informal care developed different theoretical frameworks to describe and analyse support by informal care giving. Some of the most widely are the "hierarchical compensatory model" (Cantor, 1979), the "supplementary model" (Sussman, 1976) and the "task-specificity model" (Litwak, Messeri, and Silverstein, 1990).

Cantor's hierarchical compensatory model states that following the older individual's preference for support from family, particularly spouses and children, they will become the "primary care giver" followed by other relatives, friends and neighbours, or formal organizations when close family members are not available. The model suggests that this happens in a well-ordered hierarchical selection process.

Sussman's supplementary model describes informal care as a complement to formal care where the care giver acts as the point of contact between the formal care service providers and institutions and the older individual.

Finally, the task specificity model emphasizes differences in the ability of particular individuals or groups to offer different kinds of support that will be selected by the older individual, for example selection of their care giver, in response to the activities or difficulties they need help with. In other words, it is a case of the older individuals choosing those persons that will provide them support, given their abilities rather than their kinship or other socio-demographic characteristics.

In further studies household health care, more widely known as informal care, has been considered within the broad theoretical framework of household or domestic work. Still, it is generally considered that it was Gary Becker (1976, 1988) who developed a comprehensive analysis of the household and all the activities related to it through microeconomic theories, in what is referred to as the "New Home Economics". In his theory of allocation of time, household health care activities are viewed as a decision by household members as to who has the lower opportunity costs when staying home caring for children, an ill or older family member.

Building on this, a large number of studies have used household economic theories to analyse intergenerational relations, time allocation to different activities, and utility maximisation models of the caring process to support parents whether financially, with time or with in-kind support. Other studies have focused on the nature of the decision to care in the presence of formal public services, while a wide range of studies have focused on the opportunity costs of being a care giver, mainly in terms of the labour force participation and employment of women.

Regarding the decision to care, most studies model the adult children's decision to give long-term care to their parents and try to establish whether the decision is dependent or independent of different factors such as number of siblings, marital status of the parent, health and functional status of the parent, employment status, sex, among others. Studies on time allocated to care giving activities largely use utility maximisation theory where time caring for an older family member competes with time spent on other activities such as work and leisure.

8.3 *Previous empirical Work*

8.3.1 General work

Studies regarding informal care and its determinants have focused on diverse topics such as the relations between informal care and employment-labour force participation (Henz, 2004; Evandrou and Glaser, 2003, 2004; Johnson and Lo Sasso 2000, 2006; Pezzin and Schone, 1999); between informal care and use of

formal services (Van Houtven and Norton, 2004); the extent to which publicly provided formal (paid) home care substitutes for unpaid care provided informally by family and friends (Pezzin, Kemper, and Reschovsky, 1996; Tennstedt, Crawford, and Mckinlay, 1993; Greene, 1983); the determinants of intergenerational household formation, female labour supply and informal care-giving (Pezzin and Schone 1999), among others.

One of the main issues analysed on the supply of informal care to older adults in previous literature refers to the determinants of care giving. Thus, in analysing who assumes informal care roles and factors affecting an individual's decision to care, as well as the type and intensity of care given, different socio-demographic and economic determinants, as well as household characteristics have been incorporated in different studies.

The methods used in these studies include multivariate logit or probit models of the probability of starting or continuing care (McCann, 2004, Holmes and Deb, 1998) of giving high or low intensity of care (Young, Grundy and Kalogirou, 2005), or analysis of variance (ANOVA) to investigate the determinants of help from informal or formal caregivers or a combination of both, and differences among carers (Hellstrom, Andersson, and Hallberg, 2004, Hellström and Halberg, 2004).

Within the analysis of factors predicting or determining informal care giving, it seems clear how even though the number of men caring for their parents or spouse has increased, it is still women who are doing the bulk of care giving for the older population, and when they do, they do so intensively.

Additionally, most studies find that parent characteristics such as need for help with ADL, age, and satisfaction with their own health, are the strongest predictors of their receipt of care. On the other hand, there seems to be fewer carer or potential carer characteristics that are strongly significant in predicting care giving.

It is interesting to note how although co-residence and household composition seem to be strong determinants of taking up caring activities, they are included in few studies. Additionally, although these studies include characteristics of the carer and the person cared for, they do not address potential endogeneity issues for example between health status of the older parent, and the decision and intensity of care, as well as possible additional subjective aspects of caring or of taking up different activities such as formal employment and co-residence that could have confounding effects on the estimations but are unfortunately too hard to estimate.

More recent studies have focused on the analysis of intergenerational support whether financial, in kind, or in terms of the taking up of caring activities and the bargaining process that determines parent care (Jette, Tennstedt, and Branch, 1992, Couch, Daly, and Wolf et al., 1999; Pezzin and Schone, 1999; Checkovich and Stern, 2002). Others have focused on transition or switching periods of care or support and none within the context of intergenerational household formation (Spiess and Schneider, 2003; Wong and Espinoza, 2005). Studies focus on different types of transfers between generations and find different patterns by socioeconomic, cultural, demographic background, and with different intensity and direction of the transfers. These differences could be mainly due to the different methods and data used.

Given the importance of estimating the different opportunity costs incurred by caregivers, an extensive literature has developed around the effects of informal care giving on labour force participation. The main area of interest seems to be how in terms of allocation of time, individuals have to choose between caring and employment, whether it be combining both activities, combining them but adjusting formal work time, or stopping work completely in order to care for some old or sick parent.

The majority of empirical studies on the relationship between labour force participation and care giving have been done for the United States and their results show wide variations. In recent years, various studies have been undertaken with data from the European Community, recognising the role of informal care giving as a main pillar of their welfare states on one hand, and trying to reconcile current trends with support and aid to older population and carer policies.

From these studies it is clearly difficult to estimate this relationship between labour force participation and informal care, as well as the possible causality of caring for older parents and labour force participation decisions. As a result, a wide range of contrasting results has been generated.

For example, Carmichael and Charles (2003), Johnson and Lo Sasso (2000), Pezzin and Schone (1999), Ettner (1995, 1996), Crespo (2006), Viitanen (2005), Spiess and Schneider (2003), Magnani and Rammohan (2006), Heitmueller (2005, 2007) [only women who give care at home have had a smaller probability of being employed], Heitmueller and Michaud (2006), and Casado Marín, García Gómez, and López (2006) find evidence of negative effects or strong association between starting or increasing informal care and hours of work in the sense that devoting

time to the informal care of old and/or disabled parents may be incompatible with full-time work in midlife, and find significantly lower labour force participation rates of carers compared to non-carers.

On the other hand, Wolf and Soldo (1994) conclude that they find no evidence of reduced propensity to be employed or of reduced conditional hours of work due to providing care for one's parents for a sample from the US. Other studies find combined or mixed effects such as the work of Casado Marín, García Gómez, and López (2006) who find no significant changes in the chances of being employed for those women already working before becoming caregivers, but a significant decrease in the chances of starting work for those not working prior to caring (Henz, 2006).

Similarly, these studies cover a wide range of methods used from dynamic bivariate probit models of the effects of informal care on labour force participation (Crespo, 2006; Viitanen, 2005; Heitmuller and Michaud, 2006) and ordered probit models (Casado Marín, García Gómez, and López, 2006), to more complex instrumental variable two stage and three stage simultaneous equation models, including, in some cases, the use of panel data (Heitmuller 2005, 2007; Pezzin and Schone, 1999; Johnson and Lo Sasso, 2000; Ettner 1995, 1996; Casado Marín, García Gómez, and López, 2006).

It is important to note how some studies only investigate the decision to care and who is caring (Ettner 1995, 1996; Heitmueller and Michaud, 2006; Wolf and Soldo, 1994), while others also consider the time spent caring or the intensity of such care (Crespo, 2006; Spiess and Schneider, 2003; van de Berg and Woittiez, 2005; Magnani and Rammohan, 2007).

Only a few of these studies take into account possible endogeneity between the labour force participation decisions of children and the taking up informal care giving (Wolf and Soldo, 1994; Stern, 1995; Ettner, 1995, 1996; Heitmueller, 2007; Pezzin and Schone, 1999; Viitanen, 2005; Crespo, 2006). Others try to tackle simultaneity issues around these decisions (Johanson and Lo Sasso, 2000; Heitmueller and Michaud, 2006).

This issue is of relevance given that in a context of competing demands for the child's time allocation to multiple activities, labour force participation and care giving process can be simultaneous, but also both decisions can have causal effects on each other. Also as with most estimations there can be unobserved preferences

of the carer which are related both to the propensity to care giving and of participating in the labour force.

In these studies, methods to correct for such possible endogeneity include Instrumental Variable methods mainly using two-stage least square estimations (Wolf and Soldo; 1994; Ettner, 1995, 1996; Stern 1999; Pezzin and Schone, 1999; Heitmueller, 2005, 2007), bivariate probit models of the decisions to participate in work and in caring activities (Crespo 2006), and dynamic probit models which control for unobserved individual heterogeneity, state dependence and attrition bias (Viitanen 2005). Only two studies were identified that account for both simultaneity of the decisions and unobserved individual heterogeneity, Johnson and Lo Sasso (2000) using a simultaneous equation model and panel data, and Heitmueller and Michaud (2006) who use bivariate probit models.

The main instruments used in these models include number of disabled people in the household, health status of the child's parents, the number of siblings a child has, parents' characteristics such as health status, parental education, and employment, and whether the child resides with their parents. A study for Indonesia additionally includes as instruments community characteristics such as access to electricity and piped water, asphalt roads, and public transportation as instruments that affect co-residence decisions but not directly influence the labour force participation decisions (Magnani and Rammohan 2006).

As it is noted in econometric theory, finding robust and appropriate instruments is a difficult task, mainly because in order for them to be valid instruments they have to be uncorrelated with the outcome of interest but correlated with the endogenous variable that we are trying to correct for (Greene 2008). Given the instruments chosen in the studies reviewed it seems highly difficult to assume that they are truly just affecting the determinants of care such as parent's needs or child's availability to care (endogenous covariate of care giving) and not directly affect the child's labour force participation decisions (outcome of interest).

In the cases reviewed above where, for example, parent's health status and age are assumed to affect the caregiver labour supply given an effect on the intensity of care only, or are included as instruments of informal care instead of incorporating it directly in the estimations, one could easily argue that they do have an effect both on the extensive and intensive margins of work participation besides the decision to care.

Casado Marín, García Gómez, and López (2006) state how in countries where the labour market imposes rigid work schedules and no flexible options for part-time work or caring leave, the decision to either start working, reduce hours of work or stop working at all is surely affected by the health of the parent given the absence of other options, and in spite of the high opportunity costs incurred. This is definitely the case in Mexico's labour market and legislation with corresponding effects on caring decisions (Nigenda et al., 2007; López-Ortega, Matarazzo, and Nigenda, 2007) and therefore sustaining the validity of the indicator as sound instrument would be hard to do.

As with all decision making processes, both the decision to care and the decision to participate in the labour market are likely to be affected by unobservable factors. Some examples include if the child has higher preferences for caring than working, for both giving care and working, or they may have highly altruistic views of support to parents and decide to help them (and modify their work participation decisions) even if health status or need is not extreme. It is clear how controlling for unobserved factors with instruments remains a big challenge.

The last issue reviewed is the relation between informal care (un-paid) and use of formal (publicly funded) services. Key questions addressed in studies include whether both types of care are independent or whether they complement each other. Similarly, a main topic examined has been how government expenditures or publicly funded formal care affects the likelihood of providing informal care to the older population, that is, whether formal care substitutes for informal care (Greene, 1983; Tennstedt, Crawford, and McKinlay, 1993; Pezzin, Kemper, and Reschovsky, 1996; Viitanen 2007).

Although much has been hypothesised (or feared) regarding the probability that factors such as current trends in ageing population, increased labour force participation of women and migration will cause a large increase in the demand for formal care by the older population groups, the current literature has not agreed on the effects of informal care on formal care utilisation.

Findings vary regarding the substitution effects between informal and formal care giving, and it is not clear whether they vary so widely because of differences in the specification of the models and the populations studied, or just because the effects are inconclusive.

In reviewing evidence on the substitution effects between informal and formal care, we have seen how the literature is not conclusive and shows contrasting results,

with some studies finding very small effects or effects just for a particular type of formal services.

For example, the works by Pezzin, Kemper, and Reschovsky (1996) and Greene (1983) seem to find large substitution effects of formal care for informal care, especially in communities with generous publicly funded home care programmes. Viitanen (2007) investigates the effects of government expenditure on formal care services for the older population on the incidence of informal care finding a significant negative effect (of public expenditures) for women 49-59 years old and on informal care that is done outside the carer's own household.

In their study of whether informal care provided by children or grandchildren and formal care are substitutes or complements and whether there are differences across European Countries, Bolin, Lindgren, and Lundborg (2008) found mixed effects. Informal care and formal home care were found to be substitutes, while informal care was a complement to medical doctor and hospital visits. They found different results in northern versus southern European countries. They use instrumental variable methods to account for endogeneity of informal care.

Similarly, Van Houtven and Norton (2004) address how informal care by all children influences formal care, mainly whether informal care reduces formal care utilisation of the older population and if so, what types of formal care. They find that informal care reduces total use of formal health care by the older population, primarily by reducing home health care and nursing home use. Also, they find endogeneity between informal and formal care for all utilisation types except outpatient surgery.

Despite the uncertain impact of the rapidly ageing population in Latin America, work on related issues such as informal transfers and support to the older population in the region is still scarce. One of the few such studies was performed using the Health, Wellbeing, and Ageing in Latin America 2000, SABE (United Nations Population Division, 2005). The results show that co-residence, more than the availability of living children is a main determinant of older individuals' receiving support, while number of living children seems to only positively affect the chances of older persons receiving financial assistance, especially in the case of unmarried older persons.

8.3.2 Mexico

Research on the social aspects of ageing is very recent in Mexico. As mentioned earlier few studies of the health system in Mexico have examined household health

care and in particular informal care for the older population. Of the few studies available, most rely on qualitative methods and small samples of the older population, they mostly rely on simple quantitative methods, and only one study presents an analysis of intergenerational assistance in middle and old age in Mexico. One of the main reasons has been the lack of appropriate data to generate more complete analyses that better explain the decision to care and time spent caring for the older population in Mexico.

In a first studies of care for the ill and disabled in Mexico Nigenda et al. (2007) present different patterns of time dedicated to these activities by household members. The study included an analysis of the National Time Use Survey 2002, in-depth interviews, and focus groups. They estimated that of all time spent providing care to ill and disabled persons approximately 66.4% was carried out by women and 33.6% by men. Their results show important differences in the hours delivered by gender and education level and the fact that women tend to have more responsibilities than men. In addition households tend to reorganize their structure to provide care to ill and disabled members mainly because of lack of formal care giving services.

Other studies include the work of Robles-Silva (2008), Montes de Oca (1999), and De Vos, Solis, and Montes de Oca (2004). The study by Robles-Silva (2008) analyses the caring trajectories of 21 persons who provide care for adults and older persons with diabetes, focusing on the relevance of changes in care needs and responsibilities over time.

Montes de Oca (1999) uses data from the National Socio-demographic Study of Ageing survey 1994 to investigate intergenerational relations and transfers within families in Mexico. She develops a socio-demographic theoretical framework with a focus on the strong role of families, and in particular women, as main providers of informal care needed by older adults in Mexico. Her findings show how, as in other countries, it is largely women between the age of 40 to 59 years (spouses and daughters) who are the main providers of informal care. In general, these women were married or had been in a relationship which suggests that they can also be raising their children, and thus bearing a double care-giving responsibility. In addition, it was clear that besides providing informal care women give even further support by taking care of household activities, personal care of the older individual, health care, and meal preparation, (although they may receive financial support from the older generations), while men's support for the older generation was mainly financial.

Finally, the work by De Vos, Solis, and Montes de Oca (2004) used logistic regression to analyse receipt of support among older men in Mexico. Significant predictors of whether the older man received financial assistance were living arrangements, number of children, economic activity, income and assets, and size of locality. Regarding physical assistance, significant predictors were age, living arrangements, and health status. In-kind assistance was found to be significantly determined by functional status, living arrangements, marital status, age, and employment or pension status, while domestic assistance was determined by age, living arrangements, and functional status.

In reviewing previous literature on informal care for the older population, it is important to note how with the range of perspectives that have been used to study informal care, its determinants, and the effects on other conditions (i.e. labour force participation), a similarly wide range of methods have been used for their estimation, going from simple regression analyses to complex three or four simultaneous equation models. Another thing that seems clear is that even in countries with strong formal care services household health care, and support for the older population relies heavily on informal carers, mainly family members.

Thus, it is clear that more studies are required to shed more light on these issues, especially given the increasing worries about future expenditures on formal care for the older population, women's increasing labour force participation, and migration amongst other concerns. On the other hand, it should be recognised that diversity in the populations studied, in the availability and type of formal service provision, and in the estimation methods used could be partially causing such large differences in the results.

From the review of previous literature and from the limitations of previous studies on informal care and household health care in Mexico (Nigenda, et al. 2007; López-Ortega, Matarazzo, and Nigenda, 2007; Montes de Oca 1999; De Vos, Solis, and Montes de Oca, 2004) several issues seem highly relevant and should be included in new studies of the supply of informal care to the older population in Mexico.

Besides information on the individuals receiving care, information not only on the carer but also on potential carers should be as extensive as possible, including socio-demographic characteristics, variables on health state, economic situation, labour force participation, and occupation. Also, there is a need to link this information with the characteristics, type, and intensity of care that seems to be

more prevalent in order to know what individuals are helping with and how this responds to the older person's needs.

Although it would be very interesting to know more about the effects of informal care giving, especially on Mexican women's labour force participation, such work falls outside of the scope of this thesis. Nevertheless, it remains as a relevant subject for further research.

In this context, and given the scarce literature on informal care in Mexico, this chapter reports an innovative study that estimates the supply of informal care to the older population. This extends the little work already done regarding overall status of the older population in Mexico and in particular, on the social networks available to them and the support they receive.

This work not only contributes to further knowledge in the field of health and social care of the ageing population in Mexico, but also generates relevant information for future planning of strategies to cater for their needs, and that supports the families currently taking care of their parents, grand-parents, and even great-grand parents.

8.4 Methods

Under a scenario of no long-term care services for the older population in Mexico and the fact that health services rely heavily on the family to undertake different caring activities at home, the main outcome of interest of this study is how much time young adult and middle aged children are spending on care activities for their parents, the type of activities they are taking up, and time spent in them.

The reasons why a child takes up caring activities have been studied within the contexts of sociology, anthropology, and economics and cover a wide range of theories such as parental investments and filial obligations, altruistic or self-interest reciprocity, utility maximisation of household individual's allocation of time, among others. Studies have shown how children with higher opportunity costs (such as higher paid jobs) are less likely to provide care for their parents in time and may alternatively support them with in-kind or money resources.

Cultural norms may lead some household members to take up different activities. Women, for example, may be expected to take up caring activities, independently of their working status, whereas men may be expected to be outside the household in formal employment. Finally, it seems that preferences related to the propensity or willingness to provide care to an older parent and preference for other activities

such as education, employment, voluntary work, play an important role. Although it would be interesting to investigate the possible reasons why middle-age and young adult children take up caring activities for their parents, it goes beyond the scope of this work. It would be desirable to do so in further studies.

One of the simpler ways to model the determinants of providing care to parents that has been used in a number of studies is the use of Ordinary Least Squares regressions of the time (number of hours in a determined period) spent in care giving activities.

Also, Probit and Logit models of the probability of caring decisions have been performed, controlling for different factors and characteristics of the carer and of the individual being cared for. These estimations can offer a first approximation to the subject of interest. However, by analysing the extensive and intensive margins of care separately, they assume that there is no simultaneity or endogeneity between the decision to care and the decision of how much time is to be spent caring. To assume that there is no possibility of simultaneity in these decisions or endogeneity among the variables, potentially results in a misspecification of the model and biased estimations/results.

In estimating the supply of informal care for the older population in Mexico, there were important issues that had to be considered. Regarding the typology of care it would be optimal not only to be able to estimate the extensive margin (decision to participate in care-giving) and what determines if a person is caring for an old family member, but also to explore how much time is allocated to such care and what defines the intensive margin (time spent caring). Thus, the sample of interest for the analysis is the group of children that are either caring for a parent or at risk of being carers (potential carers).

The outcomes of interest in this study are the decision to care and the time spent caring. The independent covariates entering the equations are the different characteristics of the children (carers and potential carers) such as their sex, age, marital status, main occupation, and financial situation among others; some household characteristics such as number of household members, and of potential carers; as well as age and health status of older parents being cared for.

In estimating the supply of informal care to the ageing population in Mexico, a main endogeneity issue to be considered is the causal relation between health status of the parent and care giving (both at the extensive and intensive margin). We may assume that there is a positive relationship between health status of older parents

and support from their children. However, the direction of the causality is difficult to define.

For example, if we think of different indicators of the health status of the older parent as covariates in the equation of supply of informal care that are time dependent, one can assume that past care (or absence of it) may influence present health status of the older parents, but equally, past health status may influence both the decision to care and the time spent by children caring for their older parents.

A possible approach to this endogeneity is to use instrumental variable methods to replace the potentially endogenous covariates of health of the parent with some other variable(s) that is high correlated with the outcome of interest (decision to take up care activities and type of care) but not with the error terms of the rest of covariates which influence our outcome of interest.

Given that it is hard to find good predictors of health that are also predictors of the decision to care and intensity of care, it is considered better not to follow this approach rather than going ahead with it but using weak or inappropriate instruments which can lead to equally biased and inconsistent results.

As noted earlier, estimation by Ordinary Least Squares would result in biased and inconsistent estimates. In order to account for this problem, a more accurate analysis is to use a bivariate probit model given that it is based on two binary response variables that vary jointly, and would in turn ideally also be estimated jointly. In the estimation model of care giving for the older population in Mexico, the two binary variables would be defined as care given (1=yes) and a binary variable reflecting if it is "intense" care giving or not.

Although bivariate probit models do take into account the possible simultaneity of the decisions to care and of the time spent caring, by estimating both equations separately, there is another issue to be considered. This is the fact that supply of informal care resembles behaviours such as labour force participation in the sense that there is large number of observations that present zero values; that are very close to zero; or that present high number of unobserved values.

Models that take into account censoring are more appropriate for such estimations, and a two-part Tobit model would be a preferred estimation option. Tobit models are classified within the censored regression models given that they are defined by a dependent variable that is not always observed but the main independent

variable is observed. Such censoring can happen at different values such as zero, values above some threshold, or values in between a lower and upper limit.

Tobit models involve two components, a process that determines whether the outcome variable is fully observed or not, in this case if caring for the parents is observed, and a second process that determines the quantity of the dependent variable for those individuals for whom the outcome is fully observed, the process determining how much time do children that are observed undertaking care activities spend caring for their parents. However, since the decision to care or not to care is made by the individual, those who did not care constitute a self-selected sample and not a random sample, models such as the Tobit model which do not take this into account would lead to inappropriate estimations due to sample selection bias.

To solve this selection problem, the best model to estimate the supply of informal care to the older population in Mexico seems to be a Heckman selection model. This model assumes that missing values of the dependent variable imply that the dependent variable is unobserved or not selected. For this reason it has been considered as a good way of predicting the value of the dependent variable that would be observed in the absence of selection (considering the missing values).

Although the estimation of these models could be more accurate, assumptions regarding the data available on the decision to care have to be made. That is, it must be assumed that the missing data or data on those not giving care were missing completely at random, or randomly selected out of our sample. Also, in order to include all the possible combinations of type of care and time spent caring, a model that allows for this might provide better estimations. In this sense, a categorical dependent variable model such as a Multinomial Logit Model could also be an accurate way to measure informal care for the older population in Mexico.

Thus, a Heckman sample selection model and a multinomial logit model were chosen to explore what influences the decision to care for the older population in Mexico and the decision regarding the time to be spent on caring activities.

For the estimation of Heckman selection models, a structural equation defining the determinants of time spent caring (first equation), and a selection equation predicting whether an individual will be caring or not for an older person were defined:

$Y_j = X_j\beta + v_{1j}$, where the dependent variable for observation j is only observed if $Z_j\gamma + v_{2j} > 0$, which is our selection equation. In the equation,

$$v_{1j} \approx N(0, \sigma)$$

$$v_{2j} \approx N(0, 1)$$

$$\text{Corr}(\mu_1, \mu_2) = \rho$$

This model uses information from those who took up caring activities and those who did not, allowing for the study of differences among them in determining the decision to care and time spent caring. It also analyses children living with their parents and non-resident children separately.

It has been noted that although not needed theoretically, having variables in the model that strongly affect the chances of observing the individual (selection equation) but not the outcome variable under study (time spent caring), called identifying variables, allows for the estimations not to depend on functional form for identification (Stata Base Reference Manual, 2007) (Stata 2007, p. 555).

Regarding the second model selected for this study, following Greene (2008), the model for caregivers' decision process using multinomial logit regressions is given by the probability that a person (caregiver or potential caregiver) with a vector of characteristics X_i selects an alternative j from k discrete alternatives of caring, that is:

$$\Pr(C_i = j) = \frac{e^{\beta_j' X_i}}{\sum_{k=0}^n e^{\beta_k' X_i}}$$

The model equations provide probabilities for all $j+1$ choices for each caregiver or potential caregiver (decision maker) with characteristics. X_i The model is estimated on the assumption that individuals choose the alternative that maximises their well-being (utility), with the exception of random errors. Specifically, the probabilities are defined as:

$$\Pr(C_i = j) = \frac{e^{\beta_j' X_i}}{1 + \sum_{k=1}^J e^{\beta_k' X_i}} \quad \text{for } j = 1, 2, \dots, J$$

$$\Pr(C_i = 0) = \frac{1}{1 + \sum_{k=1}^j e^{\beta_k' x_i}}$$

where k refers to the total number of caring states, and $C_i = 0$ refers to individuals who are not giving care. The log-odds of each caring state relative to the non-caring state are modelled as a linear function of individual covariates and care-recipient covariates (decision-maker: carer/potential carer).

Multinomial logistic regressions are used then to estimate the net effects of the selected covariates/explanatory variables on time spent caring for older persons in Mexico by their children. The multivariate analysis is intended to provide a statistical basis for determining the associations among three types of care and two levels of care, attributes of the children and of the older persons.

8.4.1 Statistical Analysis

The first step in the analysis was to estimate the Heckman selection models followed by the multinomial logit models.

Different studies have noted the high burden of care on children that reside with their parents compared to non-resident children as well as other differences between them in terms of taking up caring activities and the opportunity costs they incur in doing so. Given that the MHAS shows an important number of carers that are non-resident children, separate analyses were made for co-resident children and non-resident children listed in the MHAS²⁶.

Given that different types of care activities may imply differences in who provides care-giving and the time spent in such activities, two separate analyses were generated for support with ADLs and IADLs, as well as on intensity of the care given. In the survey, ADLs include walking, bathing, eating, and transferring to and from bed and from the toilet. IADLs include preparing a hot meal, shopping for groceries, taking medicines, and managing money.

Additionally, in order to try to decrease possible correlation among the different indicators of health status of the older parent, two sets of health status characteristics of the respondents were included in two separate models. In one model individual indicators of health status of the respondent such as number of chronic diseases, depression, and self-reported health were included in order to

²⁶ It could also be hypothesised that there are important differences among siblings for example in the decision to co-reside or not with parents and consequently how this affects their caring preferences and decisions.

explore their effect on the decision to care and time caring by their children (Model 1). In a second set of estimations the Frailty Index presented in Chapter 4 replaced individual health indicators and was included as a covariate representing health and frailty status of the respondents (Model 2). In the same manner, estimations were done for complete-case and multiple imputation data.

Although we could assume there is independence between households in the children's decisions to care or not for their parents and time they spend caring, this assumption does not hold within the household, that is, among children co-residing with their parents. In order to try to correct this, the multinomial regressions are also run with robust standard error estimations controlling for this non-independence within the household.

A detailed description on the relevance of generating multiple imputed data sets in order to work with a full sample instead of with complete-cases only, and the multiple imputation procedures are included in Chapter 4.

8.5 Data

The data used in this analysis come from the Mexican Health and Ageing Study (MHAS) 2001, which is a prospective panel study that included 15,230 respondents (9,806 initially identified respondents and 5,424 spouse/partners). The survey provides demographic, health, health service utilisation, and socioeconomic information on the respondents.

Additionally, the MHAS gathers data on family characteristics of the older persons including demographic and socioeconomic information on all co-residents, and all non-resident children of the selected respondents (and their spouse/partners). The questionnaire also gathered information on whether or not the respondent needed help with different activities, if the respondent received help with these activities, the relation of the carer to the respondent, and the intensity of the care received (in days per month and hours per day).

In order to estimate the models, a data set had to be generated from different sections of the MHAS survey. The final data set includes co-resident children (17,905) and non-resident children (25,169) aged 12 years and older and main characteristics that could determine their care activities both at the intensive and extensive margin.

Mexico presents high rates of migration both internationally and within the country, therefore, the initial sample of 34,756 non-resident children 12 years and older,

was analysed in order to identify those who live close to the parents and could be caring or considered potential carers. Thus, the new sub-sample of non-resident children included only those living in the same building but different house/flat, the same neighbourhood, or different neighbourhood but the same city than their parents.

Given that grandchildren and children-in-law provide significant help for household activities in Mexico, it was anticipated that they would be included in the analysis in addition to the care provided by the respondent's children. Unfortunately, this is not possible given that in the questions regarding help received when a grand-child or child-in law is identified by the respondent, the interviewer is required to write the identification number of the child he/she is related to. In addition, further information on socioeconomic and demographic characteristics are only gathered from the children of the sampled persons but not from the other household members or extended social networks.

Outcome variables

As defined in the Heckman selection models, two outcome variables were generated. A binary outcome variable to predict whether an individual will be caring or not, was generated for the selection equation. For the structural equation defining determinants of time spent caring, the outcome variable indicates the number hours per week that the individual provides care

Two variables were chosen as identification variables in the selection equation, the children's financial situation and if they have young children given that it is likely that these will affect the decision to care but will have little or no impact in the amount of care given once the individual is caring. Heckman models are fitted separately for resident and non-resident children for each type of caring activities (ADLs and IADLs).

As noted earlier, in order to achieve correct identification, Heckman selection models include at least one variable that identifies the extensive margin (selection equation) and not the intensive margin, that is, variables that are assumed to strongly affect the chances of observing the individual decision to care, but not the time spent caring.

For the multinomial logit models, initially, the categories defined for the outcome variable included 6 levels of care plus the reference outcome of no care. Categories were defined as low level of care for Activities of Daily Living, ADLs (≤ 14 hours per week of care), high level of care for ADLs (> 14 hours per week of care), low level

of care for Instrumental Activities of Daily Living, IADLs (≤ 14 hours per week of care), high level of care for IADLs (> 14 hours per week of care), low level of care for both activities simultaneously (≤ 14 hours per week of care), and high level of care for both activities simultaneously (> 14 hours per week of care).

This cut-off point was chosen after review of the studies estimating informal care for the older population groups. After an analysis of the time individuals are currently dedicating to elder care and the review of studies in other countries, the threshold between high intensity and low intensity was later defined as: a) low intensity 1-2 hours a day, and b) high intensity 3 hours and more a day. A new outcome variable was then generated with three categories: 0=No care given, 1=Care for ≤ 14 hours a week, 2=Care for > 14 hours a week. Care can be given in ADLs, IADLs or both activities. This was decided given that most carers take up both activities when caring.

However, due mainly to small number of observations (carers) in some of the categories and the fact that the highest number of observations are for both types of caring activities simultaneously, the categories were redefined according to the following diagram. Categories of care include either care for activities of daily living, instrumental activities of daily living or both as long as they correspond to the specific intensity of care.

$j=0$	No Care
$j=1$	Low intensity care (≤ 14 hours per week of care)
$j=2$	High Intensity Care (> 14 hours per week of care)

Predictor variables

It is hypothesised that women are more at risk of taking up caring activities than men and that additional responsibilities such as being married or having young children, and their occupation, will largely affect involvement or not in caring activities. Children's financial situation is also expected to have an influence on care-giving activities given that those children that are in a better financial situation may prefer to support /pay their siblings or an external carer, or provide in-kind support, rather than directly undertaking care. On the other hand, household characteristics could also have a strong effect on the decision to care or

in the time spent caring. For example, the availability of other potential carers in the household could reduce the need for others to care or to have several carers doing few hours instead of one carer undertaking all the care.

The caregiver and potential caregiver variables included in the model are: age, gender, financial situation, marital status, main activity, or occupation, and whether or not they have children under 18 years old. For the respondent and spouse, that is the individuals that are receiving or could be receiving care, the model includes relevant health variables such as an indicator of chronic diseases, if they have difficulties performing ADLs and IADLs, self-reported health, and age.

Finally, a household characteristics variable indicating the number of women in the household was included to indicate the number of additional potential carers in the household that could be taking up care-giving activities.

Other variables that were initially thought of having a potential effect on care-giving but did not and thus are not included in these final models are the children’s (carers and potential carers) education attainment and number of children, the parent’s individual income, and the total number of household residents.

Tables 8.1 and 8.2 present a definition of the variables and summary statistics for co-resident and non-resident children (carers and potential carers).

Table 8.1 Descriptive statistics of Co-resident children sample

Variable	Description	Obs.	Obs. in category	Mean	Std. Dev.	Min	Max
id	individual identifier	17998					
male	(1=yes)	17998	8,747				
age	age	17905		27.02	13.32	12	98
age group 0	12-18 years old		9,498			12	18
age group1	19-24 years old		6,874			19	24
age group 2	25-49 years old		1,533			25	49
marital	civil/marital status (1=married/in a union)	17834	4,059				
financial sit	financial situation (1=Fair/Poor)	17738	14011			0	1
occupation	activity/ main occupation (1=work/full-time student)	17681	14023			0	1
current health	currently has serious health problem (1=yes)	12651	862			0	1
num. child	num. of children	12605		0.51	1.14	0	13
young child	children under 18 (1=yes)	12571	2,634			0	1
bincare	caring for parent (1=yes)	17998	508			0	1

additional household residents	No. of additional household residents	6280	4.17	2.54	1	17
potential care	Total no. of potential female carers	6280	1.50	1.12	0	6

Table 8.2 Descriptive statistics of Non-resident children sample

Variable	Description	Obs.	Obs. in category	Mean	Std. Dev.	Min	Max
id	individual identifier	25176					
male	(1=yes)	25169	12088			0	1
age	age	23717		35.55	9.75	12	88
age group 0	12-18 years old		2578			0	1
age group1	19-24 years old		16921			0	1
age group 2	25-49 years old		4218			0	1
Marital status	civil/marital status (1=married/in a union)	24024	21810			0	1
financial	financial situation (1=Fair/Poor)	23859	17291			0	1
occupation	main occupation (1=work/full-time student)	24127	16582			0	1
current health	currently has serious health problem (1=yes)	23987	776			0	1
num. child	num. of children	23796		2.64	2	0	16
young child	has children under 18 (1=yes)	23628	17956			0	1
cares	caring for parent (1=yes)	25176	654			0	1
additional household residents	No. of additional household residents	10726		2	2.18	0	17
potential care	Total no. of potential female carers	10726		0.71	0.9	0	6

8.6 Results

8.6.1 Heckman sample selection models

Tables 8.3 and 8.4 present the results for the Heckman selection models, separately for resident and non-resident children, and for each type of caring activity (ADLs and IADLs).

8.6.1.1 Care for Activities of Daily Living, ADLs

Regarding supporting parents in activities of daily living, the models seem to explain well the decision to care but not time spent caring. This could be due to the nature of the data or also very likely because once the need for care is recognised, more than deciding how much time will be dedicated to care (assuming care is tied to the needs), the negotiation or decision between the siblings is on who will do the caring regardless of how much time is needed.

Table 8.3 Heckman selection model: Care for ADLs, co- and non-resident children

Child's characteristics	Co-Resident children				Non-resident children			
	Model 1		Model 2		Model 1		Model 2	
	Coefficient	P> z	Coefficient	P> z	Coefficient	P> z	Coefficient	P> z
male	-0.580	0.962	-3.201	0.798	10.102	0.330	-0.216	0.978
19-24 yrs old*	1.733	0.796	6.508	0.533	16.432	0.026	3.383	0.716
25-49 yrs old	9.349	0.388	-10.874	0.590	18.674	0.013	-4.859	0.630
occupation	-3.770	0.589	-19.914	0.126	-8.183	0.146	-4.638	0.402
marital status	-3.340	0.678	-7.836	0.602	0.254	0.981	-4.425	0.645
potential additional carers	-1.677	0.735	6.459	0.285	-3.710	0.422	2.012	0.658
<i>Respondent's characteristics</i>								
60-69 yrs oldΔ	2.719	0.780			-11.279	0.160		
70 years and older	9.882	0.644			-6.861	0.668		
difficulties with ADLs	-21.785	0.601			-6.202	0.673		
1 chronic disease*	-10.527	0.254			-13.156	0.035		
2-6 chronic diseases	-4.723	0.641			-0.413	0.963		
depression	-8.113	0.391			14.071	0.010		
self-reported health	4.631	0.523			-3.706	0.714		
Frailty Index score			-155.540	0.016			-33.151	0.184
_cons	76.634	0.504	231.368	0.003	32.448	0.751	92.576	0.020
<i>selection equation</i>								
male	-0.305	0.000	-0.275	0.012	-0.336	0.000	-0.370	0.004
19-24 yrs old*	-0.061	0.457	-0.060	0.597	-0.019	0.848	0.043	0.791
25-49 yrs old	0.205	0.134	0.128	0.554	-0.020	0.858	0.078	0.656
marital status	0.210	0.032	0.039	0.817	0.206	0.158	0.093	0.650
occupation	-0.125	0.129	0.044	0.740	0.072	0.360	-0.052	0.665
financial situation	0.174	0.067	0.114	0.353	0.176	0.033	-0.046	0.679
young children	-0.090	0.334	-0.303	0.049	0.116	0.167	0.107	0.399
potential additional carers	-0.121	0.001	-0.114	0.033	-0.121	0.006	-0.129	0.064
60-69 yrs oldΔ	0.221	0.014	0.388	0.002	0.133	0.208	0.168	0.316
70 years and older	0.566	0.000	0.667	0.000	0.577	0.000	0.757	0.000
difficulties with ADLs	1.120	0.000			0.536	0.000		
1 chronic disease*	0.161	0.060			-0.049	0.599		
2-6 chronic diseases	0.214	0.018			0.225	0.009		
depression	0.177	0.049			-0.042	0.635		
self-reported health	-0.079	0.350			0.260	0.010		
Frailty Index score			2.729	0.000			1.350	0.000
_cons	-2.416	0.000	-2.891	0.000	-3.416	0.000	-3.225	0.000

lambda	-14.315	0.737	-60.549	0.012	-2.824	0.924	-20.367	0.065
rho	-0.393		-0.918		-0.118		-0.822	
sigma	36.410		65.930		23.983		24.778	
Observations	10422			5958		19336		10360
Censored	10211			5879		19193		10305
Uncensored	211			79		143		55
Wald chi2	(13) 22.94			(7) 15.18		(13)		5.15
P>chi2	0.0424			0.0337		0.0128		0.6417

* Reference categories: *: 12-18 years old; Δ: 50-59 years old; *: no chronic diseases

It is important to note how, with the exception of being male, which has a negative effect on the probability of providing care, variables show clear differences between the estimations for co-resident children and non-resident children, especially regarding their own characteristics.

First, regarding the decision to care; two covariates that have a different impact for co-resident and non-resident children are their marital status and their financial situation. For co-resident children being married or in a union is significant, but not for non-resident children, while for non-resident children their financial situation appears to have a large effect on their decision to care but not for co-resident children.

In the models including individual indicators of health status, with the exception of self-reported health status of the parent which is only significant for non-resident children, the same covariates regarding the parents are significant for co-resident and non-resident children. Thus, as parents get older, have a higher number of chronic diseases, and report having difficulties with their everyday activities, the more likely it is that their children, whether they live with them or not, will take up caring activities (Model 1).

From the results it is clear how as expected, for co-resident and non-resident children, as the number of potential carers in their household increases, the probability of taking up caring activities decreases.

Additionally, in accordance with other studies, variables show the expected behaviour. Thus, being male decreases the chances of being a carer and of spending more time caring, if the child is single (including divorced, widowed) has a positive effect on caring decision, whilst having young children and additional potential carers in the house has a negative impact on the decision to care.

As expected, those in full time work or in full-time studies have a lower probability of being carers, or of spending a higher time caring. This may reflect that they have higher competing demands for their time. However, the coefficient of this variable was not statistically significant in any of the models.

When all the covariates indicating health status of the older parent are replaced with the Frailty Index score, we can see interesting differences in the results (Model 2). First, for co-resident children we see that frailty status becomes the only significant determinant regarding the time spent caring for an older parent, while for the decision to care, both covariates related to the parents, old age and frailty status are positive and highly significant. The situation for non-resident children is as in previous models where no covariates are significantly associated with the time they dedicate to caring activities.

Regarding specific characteristics of the children and the household there are interesting differences between co-resident and non-resident children regarding their decision to take up caring activities. Whereas for co-resident children having young children and additional potential carers in the household are significant in terms of reducing their likelihood of providing care, for non-resident children the only thing that seems to influence this decision is the frailty status of their parents. Also, while for co-resident children the older age of the parents is significant in determining their caring decision; this is not true for non-resident children. Finally, in these models, for co-resident and non-resident children being male continues to be significant in decreasing the chances of taking up caring activities.

8.6.1.2 Care for Instrumental Activities of Daily Living, IADLS

Similarly to the analyses of Activities of Daily Living, it is interesting to see how the model seems to explain well the decision to care, but with respect to time spent in these activities only frailty appears to be a positive and significant determinant for co-resident children (Model 2). In the case of non-resident children, only the covariate reflecting the availability of additional potential carers in the household has a significant effect on time spent caring.

Regarding the decision to care in the models for co-resident children, with the exception of being male and being middle-aged, all other characteristics of the carer/potential carer are not significant determinants.

As with the previous estimations the age of the parent, and the fact that they have difficulties performing IADLs are the most significant effects regarding their

children's decision to take up care activities. Additionally, for co-resident children having a higher number of chronic diseases is a significant determinant of the decision to care.

Table 8.4 Heckman selection model: Care for IADLs, co- and non-resident children

<i>Child's characteristics</i>	Resident Children				Non-Resident Children			
	Model 1		Model 2		Model 1		Model 2	
	<i>Coefficient</i>	<i>p> z </i>	<i>Coefficient</i>	<i>p> z </i>	<i>Coefficient</i>	<i>p> z </i>	<i>Coefficient</i>	<i>p> z </i>
male	-9.911	0.434	18.506	0.109	-22.305	0.460	-2.056	0.626
19-24 yrs old*	-2.698	0.521	2.272	0.720	10.784	0.273	4.305	0.385
25-49 yrs old	4.822	0.508	-17.340	0.223	2.418	0.842	5.366	0.287
occupation	-6.774	0.075	0.630	0.932	-3.948	0.628	-1.106	0.784
marital status	-2.159	0.618	1.060	0.903	4.875	0.726	-2.640	0.799
potential additional carers	-2.807	0.090	-4.818	0.081	-10.727	0.604	9.466	0.001
<i>Respondent's characteristics</i>								
60-69 yrs oldΔ	3.206	0.637			3.886	0.770		
70 years and older	15.448	0.233			32.175	0.431		
difficulties with ADLs	14.540	0.655			81.964	0.469		
1 chronic disease*	0.242	0.957			-3.797	0.647		
2-6 chronic diseases	5.671	0.275			10.108	0.451		
depression	-5.187	0.317			12.723	0.320		
self-reported health	6.633	0.162			5.900	0.561		
Frailty Index score			-168.311	0.003			-6.998	0.750
_cons	-0.799	0.989	194.895	0.000	-237.852	0.478	18.167	0.586
<i>selection equation</i>								
male	-0.679	0.000	-0.569	0.000	-0.306	0.000	-0.228	0.055
19-24 yrs old*	-0.002	0.979	-0.099	0.300	0.046	0.593	0.097	0.461
25-49 yrs old	0.242	0.044	0.163	0.388	-0.080	0.411	-0.187	0.253
marital status	0.101	0.235	-0.077	0.584	0.102	0.367	0.461	0.070
occupation	-0.063	0.373	-0.081	0.434	-0.044	0.520	-0.093	0.423
financial situation	0.120	0.129	0.068	0.512	-0.022	0.741	-0.071	0.501
young children	0.040	0.612	-0.030	0.800	-0.050	0.463	-0.136	0.245
potential additional carers	-0.007	0.810	0.031	0.410	-0.210	0.000	-0.165	0.015
60-69 yrs oldΔ	0.319	0.000	0.150	0.184	0.102	0.238	0.086	0.515
70 years and older	0.709	0.000	0.700	0.000	0.404	0.000	0.498	0.001
difficulties with ADLs	1.808	0.000			1.149	0.000		
1 chronic disease*	-0.010	0.895			0.017	0.833		
2-6 chronic diseases	0.160	0.034			0.106	0.189		
depression	0.147	0.081			0.113	0.119		
self-reported health	0.056	0.433			0.071	0.372		
Frailty Index score			3.628	0.000			2.585	0.000
_cons	-2.234	0.000	-2.859	0.000	-2.633	0.00	-3.487	0.000
mills lambda	12.361	0.596	-55.815	0.002	81.983	0.467	-3.277	0.700
rho	0.372		-0.980		0.998		-0.249	
sigma	33.220		56.936		81.983		13.168	
Observations	10422		5958		19336		10360	
Censored	10021		5817		19089		10295	
Uncensored	401		141		247		65	
Wald chi2	(13) 22.23		(7) 11.38		(13) 5.85		(7) 18.04	
P>chi2	0.0519		0.1230		0.9513		0.0118	

* Reference categories *: 12-18 years old; Δ: 50-59 years old; *: no chronic diseases

When the different characteristics of health status of the parent are substituted for the comprehensive indicator of frailty in the model, frailty scores together with age of the parent seem to be the only significant determinants of the decision to care (Model 2).

Although being male decreases the probabilities of taking up caring activities as in previous models, these results are only significant for co-resident children. As expected, having more potential carers in the household reduces the probability of providing care, but this seems only to be significant for non-resident children.

8.6.2 Multinomial logit regressions

The results for the multinomial logit estimations show important differences between co-resident and non-resident children. None of the characteristics of non-resident children are significant factors in the decision to provide low intensity or high intensity care versus not caring, whereas for co-resident children being married or in a fair or bad financial situation increases their likelihood of taking up low intensity of care versus no care, but has no effect on the likelihood of taking up high intensity care.

As with the Heckman models, when controlling for difficulties with IADLs, parent health characteristics such as their age, the number of chronic diseases, or being classified as cognitively impaired, are the main determinants of taking up some care activities, and of the level of care given, with the exception of high intensity of care versus no care by co-resident children. Here, the only relevant characteristics found were if parents are in the oldest age group and if they have difficulties with IADLs.

Table 8.5 Multinomial Logit models, ADLs, IADLs, non-resident children

Child's Characteristics	ADL				IADL				Frailty Index model			
	Low Intensity Care vs. No Care		High Intensity Care vs. No Care		Low Intensity Care vs. No Care		High Intensity Care vs. No Care		Low Intensity Care vs. No Care		High Intensity Care vs. No Care	
	Coeff.	p> z	Coeff.	p> z	Coeff.	p> z	Coeff.	p> z	Coeff.	p> z	Coeff.	p> z
male	-0.5085	0.008	-1.1525	0.007	-0.5969	0.002	-1.2081	0.005	-0.6666	0.020	-0.8859	0.062
19-24 years old	-0.1182	0.605	0.5708	0.354	-0.1826	0.438	0.5208	0.407	0.1097	0.737	0.5699	0.494
25-49 years old	-0.2026	0.435	0.6919	0.291	-0.3199	0.239	0.5465	0.421	-0.4301	0.268	0.6957	0.422
marital status main	0.4483	0.170	-0.0600	0.914	0.5064	0.127	-0.0616	0.912	0.6216	0.242	0.8318	0.420
occupation	-0.0109	0.954	-0.0683	0.851	0.0059	0.976	-0.1510	0.679	-0.0005	0.986	0.2836	0.541
financial situation	0.0649	0.720	0.1745	0.634	0.0340	0.854	0.1520	0.680	0.1817	0.504	-0.5225	0.195
children under 18	-0.1444	0.441	-0.1419	0.596	-0.1789	0.353	-0.1428	0.698	-0.0246	0.933	-0.1344	0.760
potential carers Respondent characteristics	-0.5800	0.000	-0.1057	0.559	-0.5626	0.000	-0.1260	0.503	-0.6967	0.000	0.0022	0.992
60-69 yrs old	0.0932	0.692	-0.4289	0.501	0.1569	0.514	-0.4223	0.513	0.3500	0.302	-0.0862	0.919
70 years +older	0.8731	0.001	1.1192	0.048	0.7594	0.004	1.0880	0.063	1.4759	0.000	2.0407	0.005
difficulties with ADLs	1.1254	0.000	1.3036	0.000								
difficulties - IADLs					2.6866	0.000	2.2104	0.000				
1 chronic disease	0.8365	0.000	-1.5820	0.005	0.5571	0.023	-1.8329	0.001				
2-6 chronic diseases	0.9937	0.000	0.0033	0.993	0.5991	0.019	-0.2745	0.470				
cognitive impairment	0.9381	0.000	1.5850	0.000	0.5895	0.002	1.3291	0.000				
depression	0.2818	0.152	-0.1181	0.791	0.1008	0.616	-0.0094	0.983				
self-reported health	0.2539	0.265	-0.0863	0.838	0.0752	0.749	-0.0576	0.891				
Frailty Index score									5.7106	0.000	4.7058	0.000
_constant	-6.0620	0.000	-6.8293	0.000	-5.8593	0.000	-6.5504	0.000	-7.2136	0.000	-9.0309	0.000
Observations	16514				16514				10360			
LR Chi2(32)	323.93				518.58				(22)			
	0.0000				0.0000				165.81			
	0.1339				0.2144				0.0000			
									0.1325			

Looking closely at the results of the multinomial logit models it is interesting to see the difference between co-resident and non-resident children in the effect of having additional potential carers in the household. While for non-resident children having additional potential carers in the household has a negative and highly significant effect for all low intensity care versus no care given, for co-resident children this effect is present in all levels of high intensity care.

This result suggests that for co-resident children giving low intensity care is probably already part of their daily activities and only when higher or more intense care is needed by the parents, are additional potential carers going to decrease their chances of being the only carers or taking up caring activities.

Table 8.6 Multinomial Logit models: ADLs, IADLs for co-resident children

Child characteristics	ADL				IADL				Frailty			
	Low Intensity Care v. No Care		High Intensity Care v. No Care		Low Intensity Care v. No Care		High Intensity Care v. No Care		Low Intensity Care v. No Care		High Intensity Care v. No Care	
	Coeff.	p> z	Coeff.	p> z	Coeff.	p> z	Coeff.	p> z	Coeff.	p> z	Coeff.	p> z
male	-0.9271	0.000	-1.3929	0.000	-1.1187	0.000	-1.5947	0.000	-0.9337	0.000	-1.3186	0.000
19-24 years old	-0.2162	0.214	0.0295	0.906	-0.2917	0.118	-0.0590	0.822	-0.2243	0.351	-0.2591	0.461
25-49 years old	0.0092	0.977	0.8355	0.014	-0.3151	0.369	0.5123	0.169	0.5585	0.211	0.1856	0.708
civil/marital status	0.4699	0.024	0.3363	0.217	0.4432	0.047	0.2601	0.359	-0.2105	0.547	-0.1349	0.753
main occupation	-0.3134	0.063	-0.4061	0.056	-0.1171	0.523	-0.1738	0.440	-0.1869	0.454	-0.0117	0.972
financial situation	0.5606	0.009	0.2662	0.288	0.5475	0.015	0.2973	0.254	0.4129	0.143	-0.0449	0.890
children under 18	-0.1263	0.521	-0.5101	0.043	0.0192	0.927	-0.3365	0.199	-0.1180	0.683	-0.2331	0.524
additional potential carers	0.0125	0.855	-0.2215	0.032	-0.0320	0.648	-0.2644	0.011	0.0616	0.507	-0.3288	0.034
<i>Respondent characteristics</i>												
60-69 yrs old~	0.3912	0.029	0.5285	0.047	0.4339	0.023	0.5492	0.046	0.0272	0.915	1.1451	0.003
70 years and older	0.9315	0.000	1.5048	0.000	0.9638	0.000	1.5842	0.000	0.5212	0.118	2.4353	0.000
difficulties - ADLs	1.7874	0.000	2.1111	0.000	3.4233	0.000	3.4124	0.000				
difficulties - IADLs	0.2731	0.144	-0.1179	0.635								
1 chronic disease					0.1451	0.457	-0.2214	0.390				
2-6 chronic diseases	0.6324	0.001	0.5016	0.033	0.5493	0.006	0.4440	0.073				
cognitive impairment	0.4352	0.041	0.7745	0.001	0.0098	0.967	0.3486	0.175				
depression	0.3394	0.078	-0.0697	0.805	0.3262	0.120	-0.0465	0.875				
self-reported health	0.0580	0.749	0.1498	0.540	-0.0925	0.626	0.0476	0.850				
Frailty Index score									7.8320	0.000	8.2005	0.000
_cons	-4.7052	0.000	-4.8591	0.000	-4.6349	0.000	-4.7399	0.000	-6.0508	0.000	-6.7512	0.000
Observations	9218				9218				5958			
LR chi2(32)	626.30				943.34				(22) 334.95			
P>chi2	0.0000				0.0000				0.0000			
Pseudo R2	0.1830				0.2755				0.1896			

It is interesting to see how for non-resident children cognitive impairment of the parent is a strong and statistically significant predictor of taking up low and high intensity care versus no care and both for ADLs and IADLs, while for co-resident children this only is the case in taking up high versus no care.

Finally, when frailty is included as indicator of the health status of the parent, child covariates are found to be non significant in determining care giving with the exception of being male which decreases the likelihood of providing low care versus no care for non-resident children, and for both low intensity and high intensity versus no care for co-resident children.

After running the multiple imputation procedures, the results for the multinomial logit estimations are quite similar with a few exceptions. Tables 8.7 and 8.8 present the results for these estimations.

For characteristics of the parents, whereas both age groups (60-69 and 70+) are significant for taking up care activities in all previous models (with the exception of low intensity of care when controlling for frailty), when using multiple imputation instead of complete-case estimations, this remains significant for taking up high intensity care in all models only in the case of co-resident children, and for low and high intensity of care for non-resident children.

Table 8.7 Multinomial Logit models: ADLs, IADLs for non-resident children, multiple imputation estimations

Child Characteristics	ADL				IADL				Frailty			
	Low Intensity Care vs. No Care		High Intensity Care vs. No Care		Low Intensity Care vs. No Care		High Intensity Care vs. No Care		Low Intensity Care vs. No Care		High Intensity Care vs. No Care	
	Coeff.	p> z	Coeff.	p> z	Coeff.	p> z	Coeff.	p> z	Coeff.	p> z	Coeff.	p> z
male (1=yes)	-0.5746	0.000	-0.8134	0.002	-0.5949	0.000	-0.8423	0.001	-0.5804	0.000	-0.8266	0.002
25-34 yrs old*	0.6357	0.063	0.1021	0.856	0.7455	0.031	0.0926	0.870	0.7259	0.034	0.1261	0.821
35-44 yrs old	0.5942	0.091	0.2534	0.654	0.6836	0.054	0.2126	0.711	0.6981	0.046	0.2531	0.652
45+ yrs old	0.3296	0.371	0.1194	0.838	0.3155	0.399	-0.0352	0.953	0.4523	0.217	0.1082	0.852
marital/civil status	0.3318	0.176	0.1233	0.750	0.2885	0.246	0.1141	0.769	0.3200	0.192	0.1494	0.699
main occupation	-0.0275	0.857	0.1929	0.430	-0.0666	0.666	0.1817	0.456	-0.0554	0.715	0.1348	0.580
financial Situation	0.2459	0.092	0.2160	0.370	0.2453	0.100	0.2076	0.392	0.1976	0.174	0.1293	0.591
children under 18	0.0222	0.886	0.0765	0.758	0.0576	0.713	0.0893	0.722	0.0181	0.907	0.0418	0.866
additional potential carers	-0.5899	0.000	0.0121	0.920	-0.6214	0.000	-0.0278	0.820	-0.6329	0.000	-0.0331	0.790
<i>Parent Characteristics</i>												
60-69 yrs old**	0.1993	0.310	0.3115	0.442	0.1839	0.356	0.2718	0.505	0.2430	0.215	0.3085	0.443
70+ yrs old	0.9072	0.000	1.6123	0.000	0.5507	0.009	1.3159	0.001	0.9627	0.000	1.6016	0.000
difficulties - ADLs	1.4154	0.000	0.6625	0.036								
difficulties - IADLs					2.8070	0.000	2.1436	0.000				
one chronic illness	0.3749	0.035	-1.0412	0.004	0.2625	0.152	-1.1727	0.001				
2-6 chronic illnesses	0.4973	0.006	0.4499	0.079	0.1268	0.502	0.1319	0.619				
cognitive impairment	0.8952	0.000	1.0707	0.000	0.5017	0.004	0.7690	0.006				
depression	0.6847	0.000	0.7791	0.002	0.4787	0.002	0.5935	0.024				
self-reported health	0.0978	0.588	0.1671	0.584	-0.0675	0.723	0.0430	0.891				
<i>Frailty Index</i>												
_constant α	-7.6596	0.000	-8.1159	0.000	-6.9043	0.000	-7.6027	0.000	6.1379	0.000	6.9318	0.000
Observations				30123				30123	-7.4955	0.000	-8.9233	0.000
												30073

Estimations for non-resident children show that the only characteristic presenting a different behaviour from the models without the imputation procedures is the age

of the child. While in the initial models age of the child was not found significant in any of the models, after imputation, it is positively and significantly associated with taking up low intensity caring activities compared to those not caring.

As in the previous estimations, once the frailty index is included to control for parent's health status, child characteristics cease to be significant (with the exception of their age for non-resident children). The estimations using the multiple imputed data show that only the availability of a number of potential additional carers, in addition to frailty status and age of the parent, are positively and significantly associated with providing care.

Finally, it is important to note how being classified as depressed has a positive and statistically significant association with the provision of different types of care and their intensity in the estimations with multiple imputation, whereas in the complete-case estimations depression was not found to be significant. This is especially the case for the models of undertaking care or help in activities of daily living, ADLs.

Table 8.8 Multinomial Logit models: ADLs, IADLs for co-resident children, multiple imputation estimations

Child Characteristics	ADL				IADL				Frailty			
	Low Intensity Care vs. No Care		High Intensity Care vs. No Care		Low Intensity Care vs. No Care		High Intensity Care vs. No Care		Low Intensity Care vs. No Care		High Intensity Care vs. No Care	
	Coeff.	p> z	Coeff.	p> z	Coeff.	p> z	Coeff.	p> z	Coeff.	p> z	Coeff.	p> z
male	-1.1190	0.001	-1.2566	0.000	-1.3156	0.000	-1.4406	0.000	-1.2350	0.000	-1.4015	0.000
19-24 yrs old	0.7010	0.183	-0.8565	0.053	0.7575	0.160	-0.7831	0.083	0.6785	0.198	-0.8754	0.050
25+ years old	0.4943	0.352	-0.4036	0.267	0.5689	0.301	-0.4510	0.246	0.5363	0.313	-0.4131	0.264
married	0.3936	0.297	0.0420	0.882	0.3631	0.347	0.1439	0.622	0.4883	0.204	0.1428	0.624
main occupation	0.2753	0.388	0.5484	0.016	0.0233	0.945	0.3203	0.190	0.2175	0.497	0.4354	0.063
financial situation	0.2353	0.530	0.4332	0.175	0.2011	0.607	0.3899	0.244	-0.0273	0.942	0.2595	0.427
children < 18 additional potential carers	-0.2066	0.565	-0.0087	0.973	-0.0437	0.906	0.1307	0.626	-0.3621	0.324	-0.1414	0.594
Parent Characteristics	-0.0935	0.503	-0.2984	0.016	-0.1350	0.359	-0.3748	0.005	-0.0710	0.613	-0.2636	0.037
60-69 yrs old	0.1536	0.663	0.5981	0.075	0.0536	0.885	0.5003	0.155	0.2036	0.558	0.6232	0.063
70+ yrs old	0.4471	0.264	1.9413	0.000	-0.2934	0.502	1.3468	0.000	0.4301	0.271	1.7627	0.000
Difficulties-ADLs	2.3762	0.000	1.0048	0.001								
difficulties-IADLs					4.1692	0.000	3.1160	0.000				
one chronic illness	0.5784	0.156	0.6508	0.037	0.5370	0.208	0.5138	0.114				
2-6 chronic illnesses	0.8378	0.044	0.9089	0.004	0.4662	0.288	0.5591	0.088				
cognitive impairment	0.9327	0.009	0.9271	0.001	0.4467	0.238	0.5610	0.061				
depression self-reported	0.2749	0.352	0.6057	0.012	-0.0548	0.863	0.3164	0.209				
health	-0.5955	0.068	0.4705	0.141	-0.6972	0.047	0.2830	0.403				
Frailty Index									8.5528	0.000	9.7266	0.000
_constant α	-7.7837	0.000	-6.8745	0.000	-6.7415	0.000	-6.1890	0.000	-7.8733	0.000	-7.5070	0.000
Observations			11097				11097				11073	

8.7 Discussion

It is clear that the labour force participation of women has steadily increased in most countries while men's participation in household activities has not changed accordingly. With the exception apparently of some countries where men do dedicate some time to child care, the burden of other activities such as care for older parents and ill family members continues to be done mainly by women.

This is particularly relevant because it has implied that for women a combination of multiple activities such as formal employment and care giving is increasing and high numbers of people are doing so worldwide. On the other hand, there are also a high number of persons that due to labour market restrictions or intensity of care needed, incur high opportunity costs and end up reducing number of hours worked or stop working altogether.

Combined with the fact that a vast majority of older individuals have a much stronger preference for staying in the community and just go to nursing care in cases of extreme need, the future may present a prospect of fewer potential carers, and less favourable conditions regarding the availability of informal care.

The aim of this chapter was to present an analysis of the supply of informal care for a nationally representative sample of Mexicans 50 years and older. This was done by studying how different health and frailty indicators of the older parents, characteristics of their children, and household characteristics impact the decision to care for older individuals, and time spent on care activities.

These analyses are an important addition to the very limited work on the supply of informal care for the older population in Mexico. By exploring the determinants of care separately for co-resident and non-resident children, and by using more advanced methods they generate more robust information with which to inform the much-needed policy debate.

The findings suggest that one of the main determinants of providing care is sex of the child where for all the models being male shows a negative and highly significant relationship with providing both low and high intensity of care. This not only supports international literature (Durán, 1999; La Parra, 2001; Pickard, 2008) but previous work on household health care in Mexico (Montes de Oca, 1999; Nigenda et al., 2007; López-Ortega, Matarazzo, and Nigenda, 2007).

It is interesting to find that it is mainly the older parent's health conditions and not the children's characteristics, that largely govern the decision to care and the time spent caring. Thus, even with high competing demands such as: formal employment outside the household; being married or in a union; and having young children, middle aged women will be the ones who provide caring activities, including high intensity of care, in response to their parents' needs.

Depression (in the parent) turned out to be a major predictor of taking up care activities for non-resident children in the multinomial logit regressions including multiple imputation, while cognitive impairment turned out to be significant for non-resident children (ADLs and IADLs) and co-resident children (ADLs). These results should be carefully considered. POINT 16, ref. to page 196 (see note at end)

In line with earlier findings, these results show that depressive symptoms are a risk factor to the development of functional dependence for instrumental activities for daily living in Mexico's older population (Ávila-Funes JA, Garant, and Aguilar-Navarro, 2007); that although it is frequent in older adults there is a very low percentage of cases that are diagnosed (Belló et al., 2005); and that at large these conditions and their repercussions are left to the family to deal with.

A similar situation is found in relation to cognitive impairment. Earlier studies have shown that high prevalence of cognitive impairment is often related to other chronic diseases and poorer health status (Mejía-Arango et al., 2007), and acts as a strong determinant of taking up caring activities for both co-resident and non-resident children. Similar results were found in all the multinomial logit models estimated in this study.

It is clear that conditions such as depression and cognitive impairment present big challenges not only for health service provision, but also for family members given the special care needs they generate. In light of an already high burden of care on the family or household, researchers and health institutions specialising in the older populations should focus on accurate and early identification of these conditions and on possible care solutions and support to the families whether in institutions or at home.

Earlier studies have shown how co-residence and distance to parents are strong determinants of care and how the burden is much higher for those children sharing the household with their parents (Ettner, 1995; Heitmeuller, 2005, 2007; Casado Marín, García Gómez, and López 2006).

From the estimation of both the Heckman selection and multinomial logit models, it is interesting to see how as expected, there were important differences between co-resident and non-resident children in terms of the decision to take up caring activities, and in the time or intensity of care given to their parents.

It is clear from the results that for co-resident children their competing demands such as being married, and having children have a significant effect on their taking up caring activities, while for non-resident children it is mostly the availability –or not- of additional carers and their financial situation that have a significant effect. Thus, non-resident children seem to care only when their financial situation is bad which could mean more of them prefer to support first with financial means and then with their time, and very likely only if no additional potential carers are available.

Finally, in terms of the covariates in the models, it is very interesting to see how the two sets of regressions included for each method and type of care, one that included specific indicators of health such as chronic diseases and depression, and the other that only included the composite measure of health and frailty (Frailty Index) produced different results. When replacing the individual health conditions by the frailty index, the child's characteristics practically cease to be significant and only the frailty index seems to be causing an effect on the decision to care and on time spent caring.

There are some limitations to this study. First, the fact that with the exception of sex, most of the carers' and potential carers' characteristics turned out not to be significant raises a question about the information collected in this survey regarding the carers and on the method of collection. Also, it should be noted how the data available seems to explain well the decision to support and care much better than it explains the time spent caring.

Unlike most of the studies of the supply of informal care to older individuals which are based on samples of carers, the Mexican Health and Ageing Study, MHAS focuses on ageing and as such, the sampled respondents' characteristics are the main interest, not the person who is caring or could be caring for them. As a bi-product of the MHAS, sampled respondents and their spouses are asked to provide information on their need for help carrying out different activities, and on those helping them with such activities and some general information about them, leaving us with indirect, potentially biased, or misinformed responses. This constitutes one of the main weaknesses of this work.

Another issue related to the limitations due to the data set is the fact that as mentioned earlier in the chapter, MHAS does not ask for any additional information about other carers apart from the respondent's children. This clearly underestimates the large amount of care done by other household members like daughters-in-law and grandchildren. In addition, it is recognised that MHAS only captures the care done in the household of the respondent, if a child is not mentioned as giving care (to their parent's), it does not necessarily mean they are not providing care at all. A non-resident daughter, for example, may not be providing care to the respondent but may be providing care to her parents-in-law. These two issues could be solved when first-hand data on carers is available, such as that obtained through a national survey on carers.

The way that information on how much time co-residents and non-resident children help their parents is collected also generated challenges for the estimations as seen by the results. Instead of detailed information on the type of activities done and the time spent on each activity in the context of total daily activities (such as that collected in time use surveys), data from MHAS only includes questions on how many days per month and hours on those days that someone helps respondents with different activities. Thus, the distribution of time spent caring is highly skewed with several respondents declaring very large number of hours per day, or all day-every day scenarios, making it harder to produce accurate measures of time spent caring and thus harder to correctly estimate a model.

Given the nature of the data set and its complexity, different models were reviewed in order to find the best estimation. Two different models, the Heckman sample selection and multinomial logit models were selected in order to capture both the decision to care and time spent caring, recognising the simultaneity of these decisions.

As noted in previous chapters, the use of a summary measure such as the Frailty Index as an indicator of overall wellbeing of the older adults should be treated with caution. In the regression results, it was seen how in some models when the frailty index score replaced separate indicators of health, it proved to be a strong and statistically significant predictor of taking up care and of the intensity of care while the child's characteristics ceased to be significant or showed a decreased effect. However, future research on the determinants of the decision to care and time spent caring for older parents should consider comparing the results of models including the frailty index with others that are more comprehensive in the number and type of individual health conditions than the ones included in this study. For

example, highly disabling conditions such as falls and fractures, or the effects of arthritis and rheumatism can be expected to produce greater needs and thus, higher demands for care and thus should be explored.

Despite the potential weaknesses, the present work is highly relevant since it is one of the first efforts to estimate the supply of informal care in Mexico, and the first to estimate supply of informal care to the older population using a nationally representative data set as compared to the previous smaller qualitative studies or those focusing on general intergenerational transfers.

Another feature of this study is the use of sample selection and multiple response discrete choice models, thus explicitly recognising that the carers do not constitute a randomly selected sample but a self selected one, and that the decision to care and time spent caring should be jointly modelled.

In a country going through continuing social and economic changes, no public long-term social and health services for the older population, and mainly family (and occasionally close friends) providing most care for the older population at home, detailed information on who is giving such care, the type and time of care given seems a national priority.

In recent years there has been an increasing interest and concern about the impact that the rapid ageing process in Mexico will have in both the social and health spheres. There is insufficient evidence on what effects this ageing process has had, and may have in the future, and no comprehensive efforts and policies, at state and national level to meet such changes. In this context, the interaction between health, social development, social security institutions, and the family is going to be of high relevance in alleviating the burden of care within the household, without generating excessive expenditures for the social and health systems.

This study estimating current supply of informal care to the older population in Mexico should be viewed as an important first attempt to have a clearer knowledge on this subject. Nevertheless, as it was noted above, important constraints in the data used leave us with many questions and ideas for further work in this area.

One of the main factors to be considered for future work are the large benefits of conducting a survey with national and state representation that gathers information directly from carers, as well as detailed data on the type of care they provide, and the time they spend, in the context of their total allocation of time to different activities.

Also, in thinking of future strategies to alleviate the burden of care on the family, special attention seems to be needed to support middle aged children, but especially women, that are currently providing most of the care activities. This is especially relevant in terms of the planning of different services or policies that should be focused on providing such carers with some respite, financial or support services in order to try to compensate for the loss in economic or financial aspects of care, but also in terms of the impacts care giving has in the overall physical and mental status of the caregiver.

Chapter 9 Final Conclusions

9.1 Introduction

This thesis explored the main conditions of a nationally representative group of the population 50 years and older in Mexico. The issues studied were health and functional ability of the older population, the determinants of their survival, their utilisation of health services and the supply of informal support they receive. These issues are considered fundamental in terms of the overall wellbeing of the ageing population.

In order to study these issues, quantitative methods were used in an assessment of health and frailty status of this population group. A Frailty Index was generated in order to have a comprehensive summary measure that could be used as input in the analyses. In order to study the determinants of different levels of disability, two econometric methods were used: a) a bivariate probit model of the presence of difficulty performing Activities of Daily Living, ADLs and Instrumental Activities of Daily Living, IADLs and receiving help in order to perform these activities; and b) an ordered probit model of disability assessed according to a modified version of Lawton and Brody's Physical and Self-Maintenance Scale (1969).

Survival analyses were performed using socio-economic and demographic predictors, as well as the Frailty Index. The methods used in these analyses include semi-parametric and non-parametric techniques, specifically, Kaplan-Meier survival estimates and Cox proportional hazards regression analyses.

Using the findings of these analyses, the utilisation of health services by this population group was estimated. Utilisation of three types of services was studied: a) physician or medical doctor visits (including first and subsequent or follow-up visits); b) ambulatory surgery or other outpatient procedures; and c) nights spent in hospital or inpatient care. Count data models were used to estimate each type of care.

Finally, the supply of informal care that children provide to support their parents in different daily activities was estimated building on the results of the disability, frailty, survival, and service utilisation analyses. In order to model both the decision to care and the intensity of such care, Heckman selection models and a multinomial logit models were used. Models were estimated separately for children residing with their parents and for non-resident children, as well as for ADLs and IADLs.

For all analyses, estimations were made using complete-case data and multiple imputation procedures in order to have data with no missing values. This allows for more robust estimations and the reduction of bias in the results due to missing values.

In the rest of this chapter, the main contributions of the thesis are presented, followed by the limitations involved in the development of the research. Implications of the research for future strategies or policies for the older population in Mexico, and for other developing countries are also discussed. Finally, recommendations for future research are presented.

9.2 *Main contributions of the thesis*

There are four main contributions from the thesis: a) advancing knowledge of the health and wellbeing of the population 50 years and older in Mexico; b) undertaking a first analysis of overall survival in this sample of the population; c) undertaking a first analysis on the supply of informal care for this population group using data on the carer, the type of care they provide, and the time they dedicate to caring; and d) contributing to academic research by applying advanced techniques and using multiple imputation procedures that allow to work with full information instead of complete-case observations only. Each major contribution is described below.

9.2.1 Health, disability, and frailty in older Mexican adults

It was noted in the thesis how there are but few studies in Mexico that explore disability in the older population in Mexico, the characteristics of those who are disabled, as well as the factors that determine the likelihood of being disabled. In addition to these issues, this study contributes by being the first to analyse the level or intensity of disability in this sample along with the factors that determine the probability of being in one or another level.

Another major contribution was the application of methods validated in other studies to generate a frailty index for this population sample. Given its inclusion of a large number of conditions, symptoms, or deficits, this index provided a comprehensive summary measure of individual scores on frailty status, in addition to a group indicator that allows for comparison among different sub-samples of the data.

Of high relevance is the fact that generating the frailty index provided an indicator that allowed the modelling of health, survival, use of health services, and supply of informal care to be tied to a summary measure of individual's well being or overall

condition. In all these studies, the frailty index showed a high predictive power and significance in the models.

The results of the studies on disability and frailty provide significant contributions by identifying and corroborating the role of different factors that increase the likelihood of being disabled or frail. For example, the findings support observations from studies in other countries or from other Mexican studies, where women accumulate significantly more deficits than men. This is the first study that corroborates this for a nationally representative sample of people 50 years and older in Mexico.

In addition it highlighted issues such as the high prevalence of depression, particularly in women, and the impact depression appears to have in overall health, disability, and overall frail status.

Most significantly, these studies have shown how there are significant differences in disability and frailty status in this sample depending on sex and socio-economic conditions. This reveals large inequalities in later life that are reflected in large differences in the way people go through the ageing process. For an important number it appears, this is done in conditions of vast disadvantage.

9.2.2 Overall survival in older Mexican Adults

This study provided, to my knowledge, the first investigation of overall survival in the population 50 years and older in Mexico and of the main factors that contribute to their risk of mortality. The study showed clear differences in mortality risk among different groups or sub-samples of this population. This information is expected to be of high relevance in the planning of future strategies for the ageing population in Mexico, not only in the scope of health services, but on the provision of social care that could modify some of the patterns.

Using different socio-economic and demographic characteristics of the individuals, as well as the frailty index as indicator of overall wellbeing, the study findings again corroborate findings from studies in other countries that show that even when women accumulate higher deficits or are frailer, men have a much higher risk of mortality than women.

In addition, the analyses showed how more than the nature of the conditions an individual has, it is the number of conditions accumulated that imposes a higher risk on their mortality.

9.2.3 Estimation of the supply of informal care to older Mexican adults

By using comprehensive information about the carers and on the time spent providing care, this study provides the first research on the supply of informal care by children to their older parents using a national representative sample of population 50 years and older. Thus, it is a major contribution to the very limited work on supply of informal care for the general as well as the older population in Mexico.

By exploring the factors that determine the decision to care and time spent providing such care separately for co-resident and non-resident children, important differences were found between the two groups. Besides contributing to research on informal care in Mexico it provides important information for policy makers as to support needed by family members providing care.

A major contribution is the demonstration of the clear excess-burden for children that live with their parents compared to non-resident children, and the fact that it is mostly women providing care. This finding has been reported in studies in other countries and this study thus corroborates this is the case also for children providing care needed by their older parents in Mexico. In addition, it shows how in spite of high competing demands such as employment or having young children, co-resident children, mainly women will provide the care needed rearranging their other responsibilities in order to do so. This corroborates the high opportunity costs related to the provision of informal care and in the case of this study, mainly for women living with their parents.

At the same time, given that there are no long-term care programmes in Mexico, these findings should be taken into account in the design and planning of social care strategies and programmes to support older adults so they include support that is evidently needed by their children and other family members.

9.2.4 Multiple Imputation procedures

Throughout the chapters it was noted how most of the previous work on the different subjects covered in the thesis was generated using complete-cases only and how this can generate biased estimation results. The studies included in the thesis were performed using complete-case and multiple imputation procedures contributing in this way to the scarce empirical studies using multiple imputation methods which allow for a fuller exploitation of available data and higher statistical reliability of the results.

9.3 Limitations

As noted in previous chapters, this study has some limitations. First, there are some limitations arising from the data used for the study. Given that the Mexican Health and Aging Study, MHAS does not yet have longitudinal data that allows for modelling causality among different outcomes, transitions, trends, or changes in state over time in the population sampled, neither the long-term impact of socio-economic conditions in their wellbeing. As a result, one of the main limitations to the analyses included in the thesis consists of being based in cross-sectional studies.

An important issue related to the MHAS data is that although it has information on help provided to the sample population in their daily activities, this data has some limitations. First, MHAS collects data on the older individuals and asks them if they receive help, from who, and how much time they spend on this. Thus, having indirect/self-reported information rather of first hand information from the carers is an important limitation, particularly compared to data from other countries where surveys focused on carers are available.

Another limitation relates to the way time spent caring or time the sampled individual receives help is recorded. MHAS asks how many days a month an individual receives help and on those days, how many hours. This clearly creates problems. For example a large proportion of people state the equivalent of receiving help "all-day, every-day" (720 hours). Although the amount of care should not be underestimated and it is likely that it represents a large part of the child's time it is clear that carers dedicate time to other activities. As opposed to time use surveys that include hour diaries or at least a listing of all activities performed each day in a "typical" week, this method of accounting for time spent in caring or time help is received presents a limitation and a more accurate estimation of this is needed.

Finally regarding the data, it is important to note that although the MHAS sample is representative of the ageing population in Mexico, currently it includes a large proportion of "younger" old adults which appear to be in good condition and not in need of help. This may create challenges to accurately estimate the conditions of the oldest old. For further waves of the study, it may be considered desirable to over-sample the oldest age groups such as for 75 or 80 years and older. This would allow for more concise and accurate estimations of the conditions of these age groups.

Secondly, there are some limitations related to the scope of the work. First, it would be necessary to investigate how the main conditions of disability, frailty, utilisation of health services, supply of informal care, and risks of mortality simultaneously interact in defining wellbeing of the older Mexican population. As noted in the chapters, there are important endogeneity issues for example, between utilisation of health services and the supply of informal care, between utilisation of health services and previous health or disability status, between supply of informal care and health or disability status, among others. Given the scope of the work and lack of accurate data, these issues were not treated for in the estimations and in the future should be addressed.

In addition, given the potential value of predicting future scenarios in the modification of current services and the design and planning of new strategies, not including projections of the main issues studied presents a limitation of the scope of the work done. A valuable extension to the current study would be to make projections regarding important factors such as the onset and transitions in frailty and disability status, utilisation of health services, and the availability of informal care.

Finally, there are two limitations in the scope of the study that have to do with the handling of the data available in MHAS and the analyses performed. The first one refers to the fact that some observations were deleted from the analyses because the interviews were performed by a proxy informant. In MHAS, a proxy interview was conducted when it was not possible to obtain a direct interview due to illness, hospitalization, or temporary absence (Wong 2004).

As it was described in previous chapters, this decision was made given that these interviews were conducted using a different questionnaire that does not include any self-reported information or administered tests such as for cognitive impairment detection, and therefore do not provide a large part of the individual's information included in the analyses. Although the fact that out of the 1 032 proxy interviews in 2001, approximately 30% were performed due to health problems of the respondent (as opposed to not being present in the household) represents a very small number in terms of the total sample of the MHAS, these individuals could shade some light regarding those that are most disabled or frail. In the future a separate analysis of the individuals with proxy interviews, particularly those proxy interviews needed due to ill health of the selected respondent should be included.

9.4 Implications

9.4.1 Mexico

From the main contributions of the thesis there are several implications for the design and planning of future long-term care services as well as for current health services.

First, there are two health conditions that constantly came up in the findings as highly significant predictors whether of disability, utilisation of health services or supply of informal care, namely depression and fractures. Both conditions have specific impacts that are highly relevant and should be included as a priority in the planning of services for the older population in the country.

A second implication of the study is the confirmation of the importance of informal care provided for the older population in their household, and the impact this may have in terms of the opportunity costs that providing care implies. Institutions at national and state level should recognise and value the care provided by family members and design appropriate strategies to support them in this difficult task. They should also recognise that even in countries where the family is considered important, as in Mexico, availability of informal care may not be the same in the future decades, and this could have significant impacts on the wellbeing of the older population.

In addition, confirmation of the high inequalities prevailing in the country has important implications. The fact that those in more disadvantaged conditions regarding their educational attainment, income, or employment are more frailty, present higher levels of disability, and higher risk or mortality clearly reflects past disadvantages and the high inequality in opportunities in access to education, employment, health services, accurate housing, among others. This should immediately be addressed so as to eliminate or at least alleviate this situation.

Finally, given the amount of research and significant findings that have been produced with the MHAS data, there is a clear implication for institutions in Mexico regarding the importance of continuing the study. Further waves of the study will provide adequate longitudinal data that will greatly increase its research possibilities and in turn the inputs generated to inform the design, planning, and possibly of evaluation of policies and programmes for the older population in Mexico.

9.4.2 Other developing countries

From the analyses and findings of this study, it is clear that the effort of having a nationally representative survey of the ageing population brings many more benefits than costs. Given the interest in this subject internationally, countries could seek for funding in order to conduct similar studies.

A specific implication for other developing countries interested in studying the wellbeing of their ageing population is the utility of generating, with already validated methods, comprehensive indicators of wellbeing such as the frailty index. As it was noted in the findings throughout the thesis, the index appears to have high power to predict diverse outcomes such as survival, utilisation of health services, or the receipt of informal care. Having the relevant data, this indicator is easy to generate and this provides an additional factor in favour of its generation elsewhere.

For other Latin-American countries where there is scarce information on the supply of informal care and its implications, the findings of this study clearly demonstrate the high burden in the households which are in the most part responsible for the care of the older parents, grandparents, etc. The investigation of all issues related to household care for the older population will give families and interested groups information for the advancement of relevant policies or strategies to address the issue of informal care for the older population.

9.5 *Recommendations for future policy*

From the analyses and results from previous chapters, the need to develop long-term care policies covering health and community care for the older population in Mexico is clear. It is also clear that the planning and implementation of such strategies involves a vast challenge. However, this should not be a deterrent for taking up the challenge and starting to work towards generating these strategies.

In 2002 the Pan-American Health Organisation in its 26th Sanitary Conference stated the need for most countries in Latin America to develop appropriate community care models for the older population while the demand is still relatively low, at least as a percentage of total population. This would avoid major problems in the next decades when the numbers and therefore the demand are likely to overwhelm the systems if current conditions are maintained.

One of the main challenges will be to move from a scheme where care is provided mostly through informal care and few private (non-profit and for-profit) institutions

that have no formal-public monitoring or regulation, to one where public community care services are provided and clear objectives, requirements, protocols of care, and expected outcomes are clearly stated and monitored constantly. Ideally these would be equally required for all public, non-profit and for-profit institutions that currently provide services and that wish to do so in the future.

A large part of this challenge will be the wide array of considerations that have to be taken into account regarding the provision of services, the target population, as well as the funds required and financing institutions. One of the first decisions concerns the target population for whom the services will be provided. Whether access to services will be universal for all Mexicans beyond a specific age, or if they will be means tested with eligibility defined, for example, by disability status, vulnerable status, poverty level, etc.

Another main consideration relates to the type of benefits or package of services that the target population will have access to and whether they will be based in institutions, at community centres, provided at the older adult's household, etc. Examples from programmes in other countries include direct cash transfers to the older person so they can allocate them as they think best to solve their needs, in-kind support such as devices or technology at home, support with personal care and home-making at the individual's household, health care provided at home, among others. Closely related to this, the structure of the programmes regarding settings and human resources, their organisation, operation, and those responsible for their execution or provision should be defined.

Because most of the care for the older population in Mexico is done at home by family members, and in most cases by women, this burden and the opportunity costs that historically have been forgone by them cannot be further ignored. Therefore, support for family members, and in particular for carers should be considered as part of future policies so their burden can be alleviated and ideally prevented in the future. Looking at experiences in other countries, some of the strategies that have been used in order to support those caring for an older family member or friend include cash-benefits, tax exemption, training in care provision, and respite care for the care giver.

As part of the design of strategies or specific programmes responding to the needs of older adults and their families, it is important to determine the role that each health and social care professional will have in the provision of services. Decisions have to be made as to whether services will primarily be developed around

geriatricians, general practitioners trained to identify and refer patients in primary care, specialised nurses, personnel trained in personal care, etc.

While developing countries already face high percentages of old population, increased demands on health and community care systems, and an additional scarcity in terms of the required labour force to provide these services, Mexico as most Latin American countries should benefit from the fact that they still have larger percent of young and working age population versus older adults, and develop a broad sector of formal health, home care, and personal care providers. This could solve an additional current problem of unemployment and extensive underemployment by better matching the labour force through specific training to the needs of the health and community care systems. Close collaboration between the Labour and Social Provision Ministry at federal and state level, academic institutions that could offer the needed ad-hoc training programmes, as well as the Health and Social Development ministries should begin as soon as the specific needs and scope of the caring programmes start to be planned.

In the Mexican context, it also seems necessary to introduce regulations or legislation, establishing minimum services to be guaranteed at federal level so that access to services is determined less by local decisions and more by the national standards of services needed to insure the wellbeing of the older population. If decentralisation of financing and responsibility for provision of long-term care is going to be in place, there has to be some guarantee that the standards defined are maintained and therefore monitoring systems should be established from the beginning.

Multi-sector collaborations seem to be a possible option to explore regarding the provision of services for the older population in the future. Given their experience in the delivery of other services, implementation of programmes and their scope of work, it is sensible to think that collaboration between the Ministry of Health and the Social Development Ministry, together with social security institutions would be optimal. Thus, according to their speciality, they could provide appropriate input in the planning stages, and in the provision of services, so they are comprehensive, non-overlapping, and cater for the different needs of the population.

Regarding specific interventions, as was seen from the results of the analyses it seems that there are some issues that require immediate attention and the feasibility of directing first efforts to attend to them should be considered. Two cases are of particular relevance, depression and fractures.

Fractures pose a special challenge to health services given the intense care they require, and to households given the high burden of follow-up care that is usually needed at home. For health services, a strategy of prevention of falls which are expected to be the highest causes for fractures seems highly recommended, and possible interventions should be evaluated. Reduced mobility or difficulty with mobility (walking, going up stairs, etc.) could be one of the main causes of fractures in older adults in Mexico. Therefore it seems urgent to conduct a diagnosis at local level of causes of fractures on one hand, and of older persons needing help (either by other persons or with devices) with their mobility together with an evaluation of the feasibility of having public funds accessible as to provide the needed support devices as a preventive strategy for falls and fractures.

In the case of depression it is necessary for health institutions in the country to have a clear idea of the national prevalence and specific burden of this and other mental health conditions in old age at local level. Even when the MHAS questionnaire on depression has been validated as a reliable indicator of depression, there are no questions that ask about diagnosis by a specialist or treatment. This may indicate that depression is not adequately detected and treated by the health services. Further studies of prevalence, determinants, and implications of depression in the older population at state and local level seem an immediate priority.

A high prevalence of depression in older adults at the Mexican Institute of Social Security, IMSS motivated a group of researchers to undertake the challenge of generating a clinical guideline for the diagnosis and treatment of depression in older adults attending their primary care services. The guideline was published in 2007 (Espinosa-Aguilar et al., 2007). They recognize that under- and delayed diagnosis of depression is common in primary care in Mexico where health practitioners consider everyday complaints, inability to cope with family stress, isolation, modification of roles in the household and economic problem as causes for depression, but see them as part of the ageing process and usually fail to offer treatment. With this in sight, they generated the guidelines with the objective of providing primary care practitioners with technical and medical tools to facilitate timely diagnosis and integral treatment of depression in older adults.

A comprehensive evaluation of the impact the application this guideline has had is undertaken as soon as possible so that after an analysis of the results, the costs, benefits, and feasibility of adopting this guideline in the rest of public institutions

should be considered, including the possible training needed for primary care practitioners, funding for treatment, etc.

In the period 2002-2003, IMSS launched the Integrated Health Programmes strategy (Programas Integrados de Salud) known as PrevenIMSS²⁷. Comprehensive prevention care guidelines for four age groups were generated: children, adolescents, adults (separate guidelines for men and women), and older adults 59 years and older. With respect to older adults, the guidelines focus on health education and promotion (including exercise, oral health, accident prevention); adequate nutrition; disease prevention and control; timely detection of disease and other ailments; and sexuality. The programme operates in all IMSS Family Medicine Units (primary care). Given its comprehensive nature, the large effort it represents within the context of IMSS, and its years of operation, a further recommendation is undertake comprehensive impact, outcome, and economic evaluations of the programme and from the results consider the benefits and feasibility of replicating the strategy in other public institutions in the health system.

As part of these recommendations, it would be desirable that from their inception and generation, strategies or programmes should include impact and economic evaluation instruments, process and outcomes measurement, in order to constantly evaluate and monitor their impact on the health and wellbeing of the older population and the attainment of objectives.

Surely, one of the main challenges concerns the funds and financing mechanisms needed to implement the different strategies. Following local-level comprehensive analysis of the needs of the older population and the services required to meet them, local and federal-level collaboration should be considered, as well as among different institutions.

In light of scarce funds, the scheme established by the Seguro Popular in order to obtain universal insurance and coverage in health could be a feasible model to use. This could be done by extending the programme in order to include a much wider scheme of interventions for the older population, comprehensive prevention strategies, or by replicating it to create a parallel insurance long-term care scheme initially for the most disadvantaged so they are not left without any care, but set-up as to attract working class and professional sectors who could contribute with some funds throughout the years according to their earnings or economic possibilities, generating that way alternative funding and service provision schemes.

²⁷ Comprehensive information can be consulted at: <http://www.imss.gob.mx/programas/prevenimss/index.htm>

Inclusion of the voluntary sector under close regulation and monitoring, and following guidelines established by public institutions, seems an additional alternative to the provision of services, particularly given scarce funds and the wide array of needs faced in the health and social development sectors.

9.6 *Recommendations for future research*

In light of the evident need for long-term health and social care for the older population in Mexico, rather than replacing the family, there is an urgent need to find ways to support family members, and in particular those providing care, in order to limit, alleviate, or end their burden. An initial recommendation for future research is to obtain first hand information on carers by collecting data at national and state-local level to have a better knowledge and understanding on their contribution and the opportunity costs faced in doing so. From that information, appropriate policies and support strategies could be adequately determined.

In order to do this, it is necessary to design and implement a nationally representative survey on carers that provides information on who is providing this care, who are they caring for, what activities they undertake and how much time they spend doing so. Socio-economic and demographic characteristics, opportunity costs forgone, as well as a diary of activities that includes caring tasks should be included in the survey. In addition, first hand information from carers or future "clients" of carer-support programmes should be obtained in order to investigate what are their thoughts and preferences regarding different support schemes, such as cash benefits, in-kind support, provision of personal care at home, as well as non-financial support such as training, respite care, among many other possibilities. Not only will this provide appropriate data to conduct the necessary research, but also it will provide inputs for the design and planning of long-term social and community care towards the alleviation of the burden of care and its consequences, and the choice of care services that better serves their needs and preferences.

Although there were no statistical differences between urban and rural communities in general in this study, rather than there being none, it is more likely that the way this is measured in the MHAS is probably not a sound indicator of possible differences between localities. Therefore, a second research recommendation is to replicate these studies at the state- or local-level in order to investigate if such differences exist or not. In particular, it is recommended that the analyses of this thesis regarding, disability, frailty status, and survival should be performed at a state or local level as to have first hand information that is of value to local

authorities in their respective planning of health and/or social care strategies for the older population.

Given that MHAS has national level representation but no public data on the state or municipality the respondent, it is likely that other sources of information will be needed in order to be able to undertake these studies. A likely method would be to try and link administrative-type data, for example from the Census, Ministry of Health registries, the National Council of Population, CONAPO, and the National Institute of Statistics, INEGI so as to obtain local level data and possibly simulate longitudinal data. This method of linking administrative data is used, for example, by the Census office in the United Kingdom. Although this may constitute a great effort, the results obtained and their expected use as inputs in further planning or modification of current services seems a small price to pay.

Through the thesis, it was noted how currently there is a lack of sound information on the number of institutions, mainly for profit and non-profit, that provide different services for the older adults, from day-centres to full institutionalisation. It is therefore recommended that using data from the Census 2010, a detailed count of such institutions is done in order to generate a national registry, and ideally in time, there is an evaluation/assessment of the impact they are having on the older population's wellbeing one hand, and of their infrastructure (suitability), operation, costs, and process of service provision, on the other.

Albeit few in number, the Census 2000²⁸ included for the first time a set of questions on disabilities. If these are again included in the Census 2010, an additional research recommendation emerges as we would have two periods, and at least one transition period, in which to study disability in the older population in Mexico. One major advantage of undertaking such work will be the use of detailed data on demographic and socio-economic characteristics, characteristics of the household, and place of residency by municipality that the Census includes.

Finally, in these efforts, collaboration with researchers and possibly long-term care agencies in other countries should be sought-after. Two possible reside in the United Kingdom and Spain. In the first case, the United Kingdom has a long history of design, implementation, financing, and evaluation of long-term social or

²⁸ The Census is carried out by the National Institute of Statistics, Geography and Informatics. Its unit of observation are all private and collective (hospitals, hotels, convents, dorms, jails, etc.) households and all persons living in them, in addition of those with no home. It is carried out door to door and the questionnaire is applied to all residents. The specific question on disabilities asks for all residents if the person: a) has limitations to move or walk; b) has limitations to use their arms and hands; c) is deaf or uses a hearing device; d) is mute; e) has some mental deficiency/impairment; f) any other physical or mental limitation (open-ended question). In addition, the survey asks about such limitation(s): a) if the person was born with them; b) are result of an illness or disease; c) are result of an accident; d) are result of old age; or e) any other cause (open-ended question).

community care and their experience would be highly valuable in the process, from design to evaluation of related strategies in Mexico.

The second case is that of Spain. Until very recently, Spain had practically no services that catered for the older population. In 2006, a new law on dependency of the older population was approved and with it the reform of existing services and the planning of new ones were developed. Thus, given their previous context of scarce services and high reliance on informal carers to provide most long-term care, their experience in the planning of services, legal requirements, and political negotiations surrounding the process could also be of great value to the development of future long-term care policies in Mexico.

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Appendix 1 Multiple Imputation procedure: Stata do-file

```
#delimit ;
ice height weight male edad murb entmig indlang heapr_10 edulev qtydrk qtysmok physwk hypert diab
cancer respill heart stroke arthrit feet diff_breath vertigo thirst fatigue wheez legpain stompain
urineloss paintyp h1 h4 h5 h8 h9 h10 h11 h12 h13 vision hearing c52a c52b c52c c52d c52e c52f c52g
c52h c52i fractures srhea best_ab bstdelay_ab fig_copy fig_recall vis_scan h26_1 h27_1 h28_1 h29_1
works outpatient inpatient md_visits ed0 ed1 ed2 drk0 drk1 drk2 drk3 smk0 smk1 smk2 smk3 pain0
pain1 pain2 pain3 vi0 vi2 vi4 vi6 vi8 vi10 hear0 hear2 hear4 hear6 hear8 hear10 srh0 srh25 srh50 srh75
srh100 figco0 figco1 figco2 figrec0 figrec1 figrec2 using imputed, m(10)
passive(ed0:edulev==0\ed1:edulev==1\ed2:edulev==2\drk0:qtydrk==0\drk1:qtydrk==1\drk2:qtydrk==2\
drk3:qtydrk==3\smk0:qtysmok==0\smk1:qtysmok==1\smk2:qtysmok==2\smk3:qtysmok==3\pain0:paint
yp==0\pain1:paintyp==33\pain2:paintyp==66\pain3:paintyp==100\vi0:vision==0\vi2:vision==2\vi4:visio
n==4\vi6:vision==6\vi8:vision==8\vi10:vision==10\hear0:hearing==0\hear2:hearing==2\hear4:hearing==
4\hear6:hearing==6\hear8:hearing==8\hear10:hearing==10\srh0:srhea==0\srh25:srhea==25\srh50:srhe
a==50\srh75:srhea==75\srh100:srhea==100\figco0:fig_copy==0\figco1:fig_copy==1\figco2:fig_copy==2\
figrec0:fig_recall==0\figrec1:fig_recall==1\figrec2:fig_recall==2)
substitute(edulev:ed0 ed1 ed2, qtydrk: drk0 drk1 drk2 drk3, qtysmok: smk0 smk1 smk2 smk3, paintyp:
pain0 pain1 pain2 pain3, srhea: srh0 srh25 srh50 srh75 srh100, fig_copy: figco0 figco1 figco2,
fig_recall:figrec0 figrec1 figrec2) cmd(edulev:ologit, qtydrk:ologit, qtysmok:ologit, paintyp:ologit,
vision:ologit, hearing:ologit, srhea:ologit, fig_copy:ologit, fig_recall:ologit) eq(height:male edad indlang
entmig heapr_10, weight: height male edad indlang entmig murb heapr_10 ed0 ed1 drk0 drk1 drk2
smk0 smk1 smk2 physwk, indlang: edad murb entmig, heapr_10: male indlang murb entmig, edulev:
male edad indlang entmig murb heapr_10, qtydrk: male edad indlang murb entmig smk0 smk1 smk2
physwk ed0 ed1, qtysmok: male edad indlang murb entmig drk0 drk1 drk2 physwk ed0 ed1, physwk:
weight male edad indlang murb entmig drk0 drk1 drk2 smk0 smk1 smk2 heapr_10 ed0 ed1, hypert:
height weight male edad indlang murb entmig drk0 drk1 drk2 smk0 smk1 smk2 physwk heapr_10 ed0
ed1 diab heart stroke, diab: height weight male edad indlang murb entmig drk0 drk1 drk2 smk0 smk1
smk2 physwk heapr_10 ed0 ed1 hypert feet thirst legpain, cancer: height weight male edad indlang
murb entmig drk0 drk1 drk2 smk0 smk1 smk2 heapr_10 ed0 ed1, respill: height weight male edad
indlang murb entmig smk0 smk1 smk2 heapr_10 ed0 ed1 diff_breath wheez, heart: height weight male
edad indlang murb entmig drk0 drk1 drk2 smk0 smk1 smk2 physwk
heapr_10 ed0 ed1 diab, stroke: height weight male edad indlang murb entmig drk0 drk1 drk2 smk0
smk1 smk2 physwk heapr_10 ed0 ed1 diab hypert, arthrit: height weight male edad indlang murb
entmig drk0 drk1 drk2 smk0 smk1 smk2 heapr_10 ed0 ed1 legpain, feet: height weight male edad
indlang murb entmig heapr_10 diab, diff_breath: height weight male edad indlang murb entmig smk0
smk1 smk2 heapr_10 respill, vertigo: height weight male edad indlang murb entmig heapr_10 hypert
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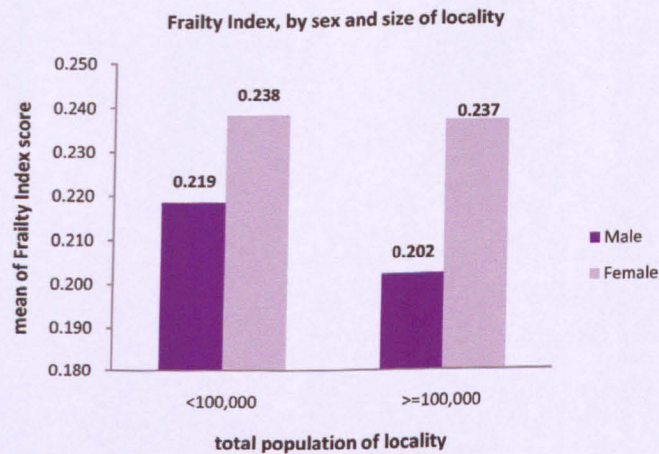
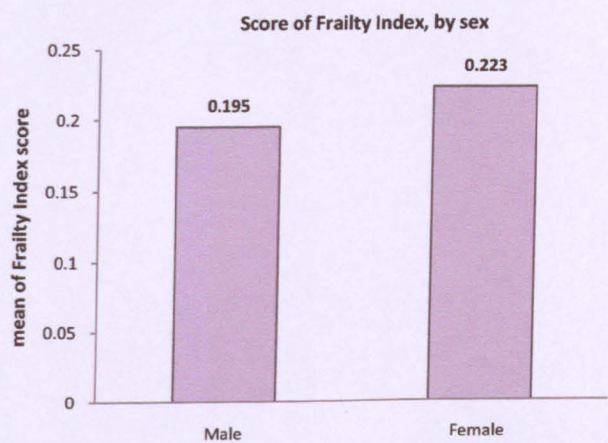
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 diff_breath vertigo fatigue legpain stompain urineloss pain1 pain2 pain3, h4: height weight male edad indlang murb entmig heapr_10 ed0 ed1 arthrit legpain pain1 pain2 pain3, h5: height weight male edad indlang murb entmig heapr_10 ed0 ed1 arthrit legpain pain1 pain2 pain3, h8: height weight male edad indlang murb entmig heapr_10 ed0 ed1 arthrit legpain pain1 pain2 pain3, h9: height weight male edad indlang murb entmig heapr_10 ed0 ed1 arthrit pain1 pain2 pain3 stroke, h10: height weight male edad indlang murb entmig heapr_10 ed0 ed1 arthrit pain1 pain2 pain3 stroke, h11: height weight male edad indlang murb entmig heapr_10 ed0 ed1 arthrit pain1 pain2 pain3, h12: height weight male edad indlang murb entmig heapr_10 ed0 ed1 arthrit legpain pain1 pain2 pain3, h13: height weight male edad indlang murb entmig heapr_10 ed0 ed1 arthrit legpain pain1 pain2 pain3, vision: male edad indlang heapr_10 ed0 ed1 diab stroke arthrit, hearing: male edad indlang heapr_10 ed0 ed1, c52a: male edad entmig murb ed0 ed1 hypert diab cancer respill heart stroke arthrit pain1 pain2 pain3 feet diff_breath fatigue legpain stompain urineloss h1 h4 h5 h8 h9 h10 h11 h12 h13, c52b: male edad entmig murb ed0 ed1 hypert diab cancer respill heart stroke arthrit pain1 pain2 pain3 feet diff_breath fatigue legpain stompain urineloss h1 h4 h5 h8 h9 h10 h11 h12 h13, c52c: male edad entmig murb ed0 ed1 hypert diab cancer respill heart stroke arthrit pain1 pain2 pain3 feet diff_breath fatigue legpain stompain urineloss h1 h4 h5 h8 h9 h10 h11 h12 h13, c52d: male edad entmig murb ed0 ed1 hypert diab cancer respill heart stroke arthrit pain1 pain2 pain3 feet diff_breath fatigue legpain stompain urineloss h1 h4 h5 h8 h9 h10 h11 h12 h13, c52e: male edad entmig murb ed0 ed1 hypert diab cancer respill heart stroke arthrit pain1 pain2 pain3 feet diff_breath fatigue legpain stompain urineloss h1 h4 h5 h8 h9 h10 h11 h12 h13, c52f: male edad entmig murb ed0 ed1 hypert diab cancer respill heart stroke arthrit pain1 pain2 pain3 feet diff_breath fatigue legpain stompain urineloss h1 h4 h5 h8 h9 h10 h11 h12 h13, c52g: male edad entmig murb ed0 ed1 hypert diab cancer respill heart stroke arthrit pain1 pain2 pain3 feet diff_breath fatigue legpain stompain urineloss h1 h4 h5 h8 h9 h10 h11 h12 h13, c52h: male edad entmig murb ed0 ed1 hypert diab cancer respill heart stroke arthrit pain1 pain2 pain3 feet diff_breath fatigue legpain stompain urineloss h1 h4 h5 h8 h9 h10 h11 h12 h13, c52i: male edad entmig murb ed0 ed1 hypert diab cancer respill heart stroke arthrit pain1 pain2 pain3 feet diff_breath fatigue legpain stompain urineloss h1 h4 h5 h8 h9 h10 h11 h12 h13, fractures: height weight male edad indlang murb entmig heapr_10 ed0 ed1 drk0 drk1 drk2 smk0 smk1 smk2 physwk legpain h1 h5 h8 h9 h13 pain1 pain2 pain3 works, srhea: height weight male edad indlang murb entmig ed0 ed1 works drk0 drk1 drk2 smk0 smk1 smk2 physwk

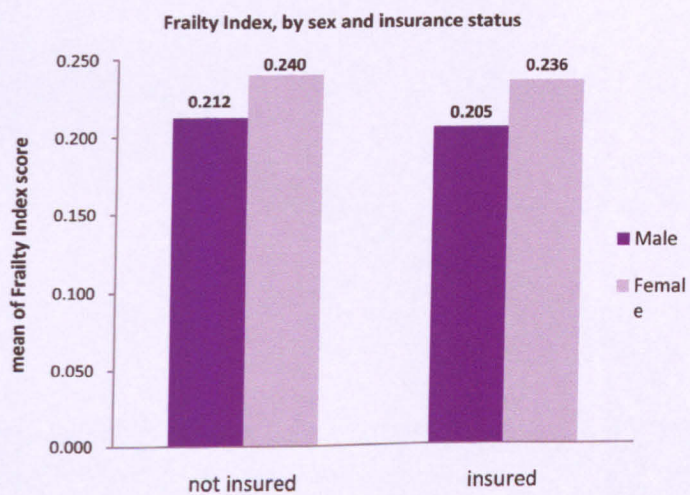
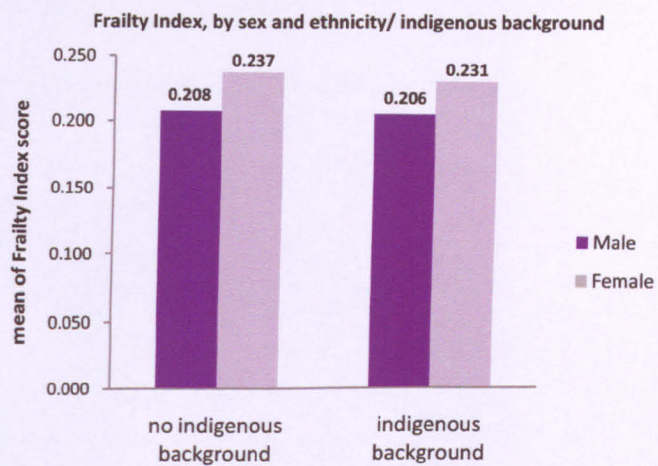
heapr_10 hypert diab cancer respill heart stroke arthrit feet diff_breath vertigo thirst fatigue wheez
 legpain stompain urineloss pain1 pain2 pain3 h1 h4 h5 h8 h9 h10 h11 h12 h13 h26_1 h27_1 h28_1
 h29_1 c52a c52b c52c c52d c52e c52f c52g c52h c52i fractures, best_ab: male edad ed0 ed1 diab heart
 stroke arthrit c52a c52b c52c c52d c52e c52f c52g c52h c52i, bstdelay_ab: male edad ed0 ed1 diab
 heart stroke arthrit c52a c52b c52c c52d c52e c52f c52g c52h c52i, fig_copy: male edad ed0 ed1 diab
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 fatigue legpain stompain urineloss h1 h4 h5 h8 h9 h10 h11 h12 h13 pain1 pain2 pain3 srh25 srh50 srh75
 srh100, outpatient: height weight male edad indlang murb entmig ed0 ed1 works drk0 drk1 drk2 smk0
 smk1 smk2 physwk heapr_10 hypert diab cancer respill heart stroke arthrit feet diff_breath vertigo
 thirst fatigue wheez legpain stompain urineloss pain1 pain2 pain3 h1 h4 h5 h8 h9 h10 h11 h12 h13
 h26_1 h27_1 h28_1 h29_1 c52a c52b c52c c52d c52e c52f c52g c52h c52i fractures best_ab bstdelay_ab
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 feet diff_breath vertigo thirst fatigue wheez legpain stompain urineloss pain1 pain2 pain3 h1 h4 h5 h8
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 c52g c52h c52i fractures best_ab bstdelay_ab figco0 figco1 figrec0 figrec1 vis_scan) seed(7240) ;

Appendix 2 Frailty Index indicators

Descriptive statistics Frailty Index score, pooled sample and by sex

Frailty Index	obs.	mean	std. dev.	var.	skewness	kurtosis	min.	max.
Pooled sample	6810	0.210	0.119	0.014	0.90	3.52	0.00	0.77
Female	3525	0.223	0.127	0.016	0.76	3.06	0.01	0.77
Male	3285	0.195	0.117	0.012	1.02	4.10	0.00	0.70





Appendix 3 Survival Analyses

Test of proportionality of the Cox regression models

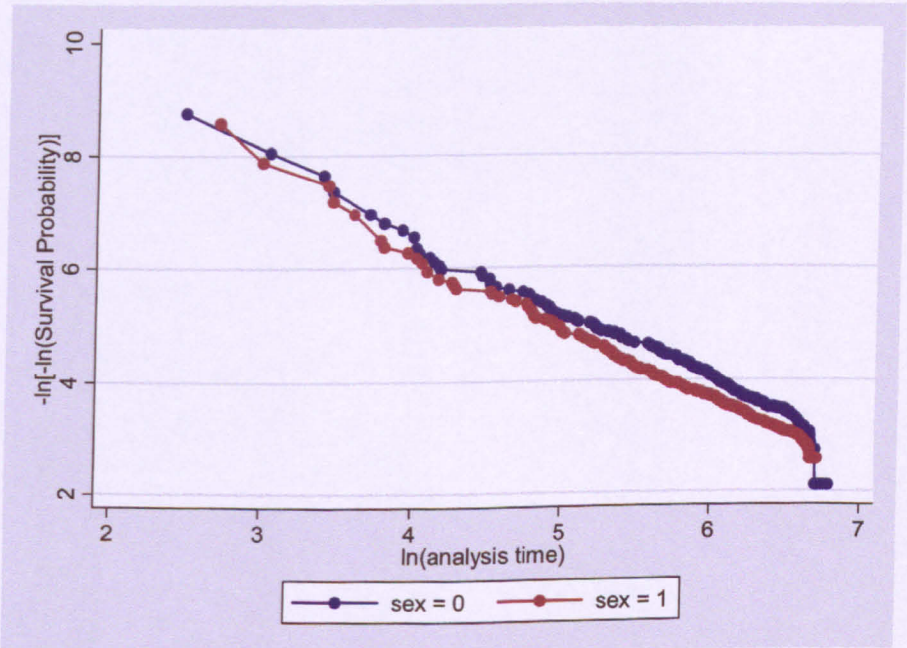
Model 1

Test of proportional-hazards assumption

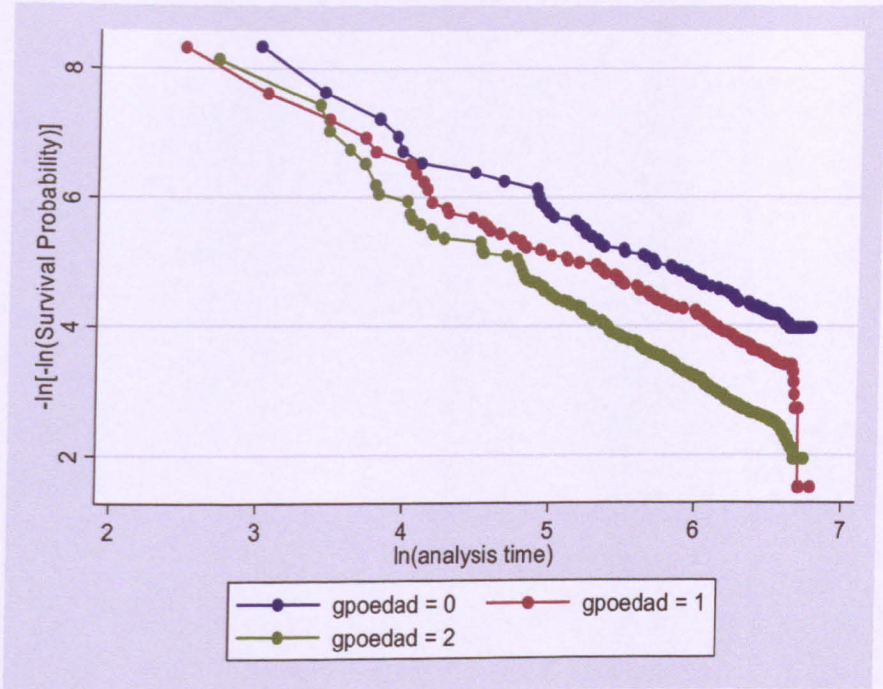
Time: Rank(t)				
	rho	chi2	df	Prob>chi2
sex	-0.05118	1.09	1	0.2959
_igpoedad_1	0.08058	2.74	1	0.0976
_igpoedad_2	0.08652	3.21	1	0.0730
marst	0.04823	0.95	1	0.3302
_iedulev_1	-0.00773	0.03	1	0.8728
_iedulev_2	0.07121	2.19	1	0.1388
global test		9.17	6	0.1641

Proportional Risks by different categories

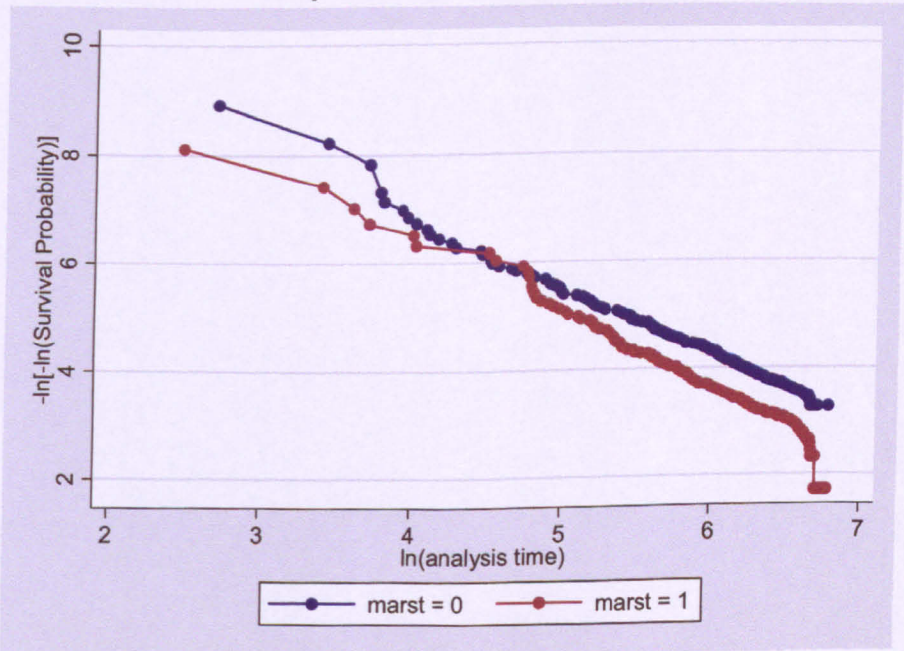
Proportional Risks by sex



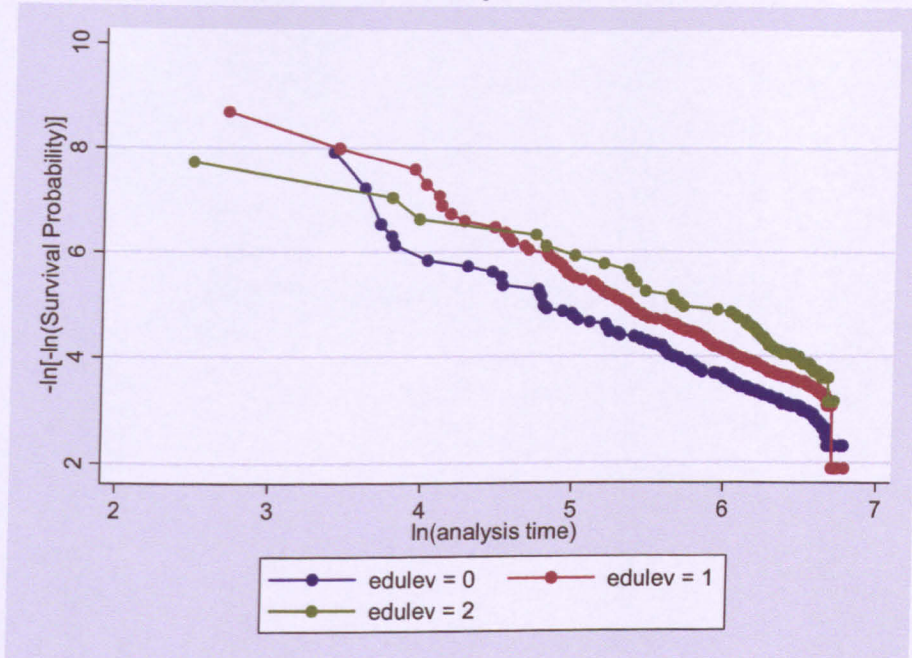
Proportional Risks by age group



Proportional Risks by marital status



Proportional Risks by educational attainment



Categories:

formal education
(edulev):

0= no formal
education
1= completed Primary
education
2= completed at least
Secondary education

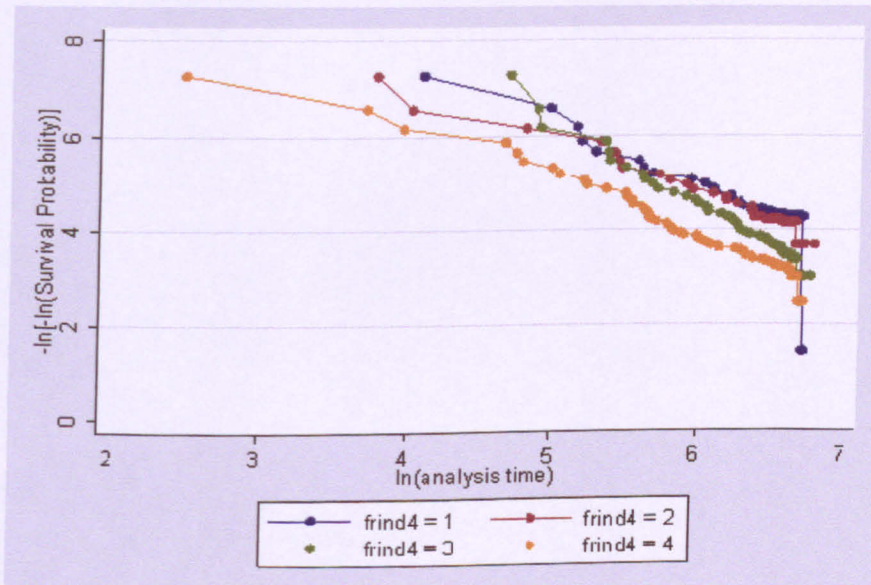
Model 2

Test of proportional-hazards assumption

Time: Rank(τ)

	rho	chi2	df	Prob>chi2
sex	-0.05789	0.50	1	0.4809
_Iqpoedad_1	0.18427	5.24	1	0.0220
_Iqpoedad_2	0.05097	0.41	1	0.5201
marst	0.10698	1.69	1	0.1937
_Iedulev_1	-0.01502	0.03	1	0.8527
_Iedulev_2	0.04676	0.34	1	0.5610
_Ifrind4_2	0.00304	0.00	1	0.9704
_Ifrind4_3	0.10610	1.63	1	0.2011
_Ifrind4_4	-0.00021	0.00	1	0.9980
global test		13.41	9	0.1448

Proportional Risks by quartiles of Frailty Index



Categories of Frailty Index
(frind4):

quartile1=1 (less frail)
quartile2=2
quartile3=3
quartile4=4 (highest frailty)